ORISSA'S DECADE OF DESTINY
1963-1973

A MASTER PLAN FOR
THE INTEGRATED DEVELOPMENT OF
THE RIVER BASINS OF ORISSA

taken from

THE SIXTH SIR M. VISVESVARAYA LECTURE

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by

DR. A. N. KHOSLA, Governor of Orissa
Honorary Life Member, Institution of Engineers (India)
Life Member, American Society of Civil Engineers

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SUMMARY

This is a Master Plan for the Integrated Development of the River Basins of Orissa. The Plan reveals the promise and the hope of tomorrow, the Destiny of Orissa in the Decade 1963—73 and the new opportunities for development in Orissa and the adjoining States of the Eastern Region in the years following.

It is a Multi-State Plan, providing complete flood control of the Mahanadi, Brahmani and Baitarani rivers, irrigation facilities to Orissa, West Bengal and Andhra ; inland navigation to the Haldia, Visakhapatnam and Paradeep Ports and their hinterlands through a net-work of irrigation-*cum*-navigation canals ; and additional power to West Bengal, Bihar, Madhya Pradesh, Andhra Pradesh and possibly U. P. and Maharashtra.

The over-all benefits of the Master Plan and its component units will be:

——	Total Master Plan	New River Valley Projects and Hydro Power	Thermal Power	Core Project of Master Plan	Tikerpara Power Project	Units
Cost ..	1,621	825	590	469	175	Rs. crores
Flood control—						
Mahanadi	Complete	Complete	..	Complete	Complete	
Brahmani	Complete	Complete		..	..	
Baitarani ..	Complete	Complete	..	..	..	
Irrigation—						
Orissa	9·0	5·3		4·3	..	Million acres of crops.
West Bengal	1·0	1·0		1·0		,,
Andhra Pradesh	1·0	1·0	..	1·0	..	,,
Power—						
Hydro (30% L.F.) ..	8·44	7·49	..	4·29	2·00 *	Million K.W.
Thermal ..	9·0	0·5	8·5	0·25		
Navigation canals and reservoirs.	1,230	1,200		795	..	Miles
Water spread for fish culture & recreation.	1·25	1·00		0·65	0·65	Million acres

* 41·25% L. F.

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The total Master Plan will cost Rs. 1, 621 crores and be completed in the Eighth Plan.

Rs. 206 crores out of this have been or will be spent on projects completed or under construction—including installation of 250 M.W. of thermal power at Talcher.

Rs. 825 crores (River Valley Projects and Hydro Power) will be needed to complete all the new river valley projects to provide complete flood control of the Mahanadi, Brahmani and Baitarani rivers ; irrigation; hydro power and navigation facilities plus the installation of an additional 250 M.W. of thermal power at Talcher. This part of the Plan will be completed by 1983.

Rs. 590 crores (Thermal Power Project) will be the cost of generating an additional 8,500 M.W. of thermal power with Talcher coals and/or with middlings at the Bengal-Bihar coal washeries. This part of the Plan will continue into the Eighth Plan possibly to the year 1991.

Rs. 469 crores (Core Project of the Master Plan) of the Rs. 825 crores Plan will be needed to complete the Core Project of the Plan—the Tikerpara-Gania complex. Irrigation part of it will continue in the Fifth or even the Sixth Plan.

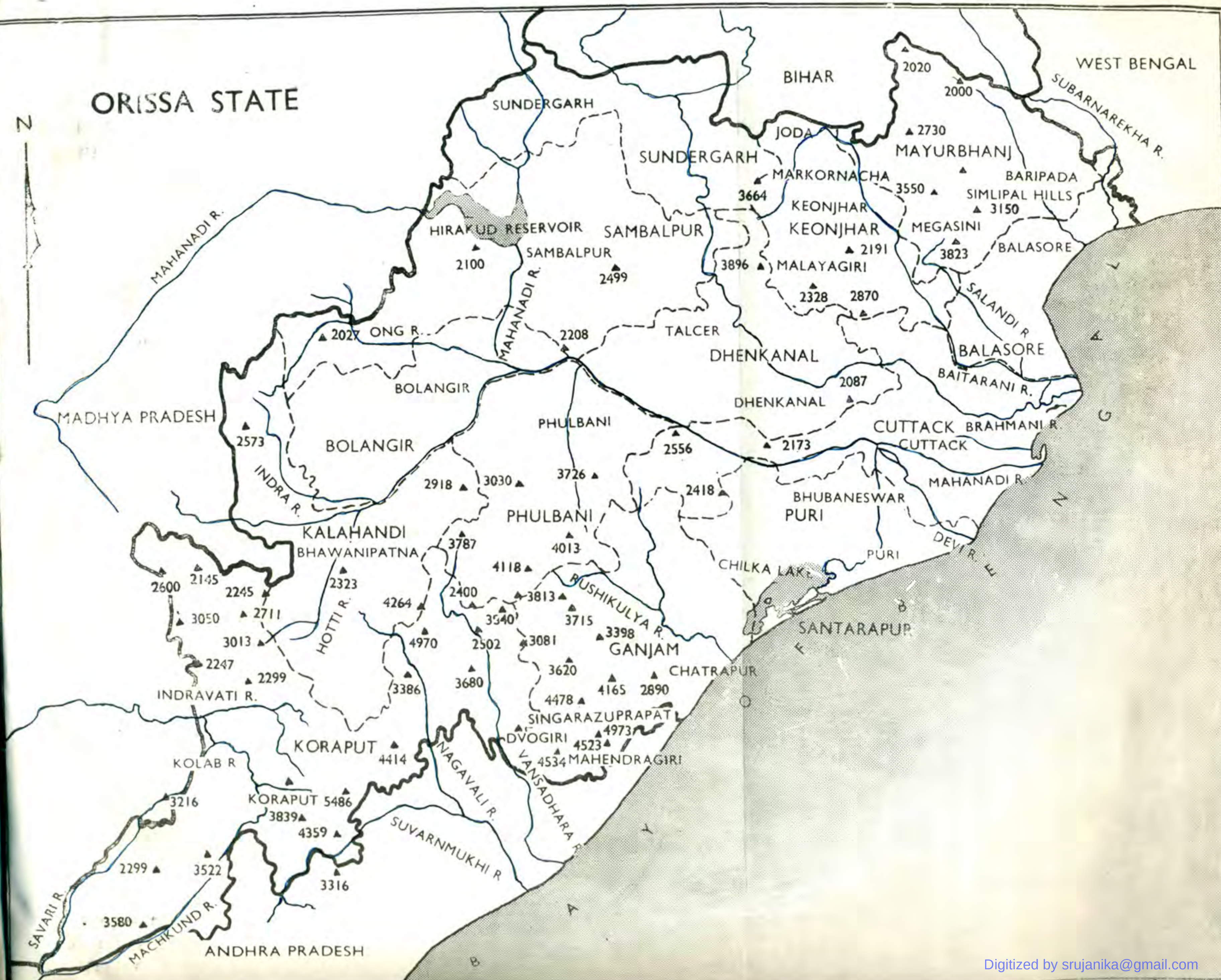
Rs. 175 crores of the Rs. 469 crores will be required for the completion of the Tikerpara Power Project and Gania Barrage to minimum essential level with small part of canal system under way during the period 1963-73, Orissa's Decade of Destiny. This part of the Plan will be executed in two Stages—

Stage I will cost	Rs. 108 crores ,	and bring
gross receipts	Rs. 10·2 crores ,	from which deduct
fixed charges	Rs. 6·25 crores ,	leaving
net return of	Rs. 3·95 crores ,	per year
Stage II together with		
stage I will cost	Rs. 175 crores ,	and bring
gross receipts	Rs. 50 crores ,	from which deduct
fixed charges	Rs. 10·44 crores ,	leaving
net return of	Rs. 39·56 crores ,	per year
	with power sold at Rs. 250	per KW year.

Foreign exchange required	for Stage I	Rs. 15·0 Crores
and	for Stage II	Rs. 5·5 Crores
or a	Total of	Rs. 20·5 Crores

THIS NET RETURN OF NEARLY 40 CRORES A YEAR WILL TRANSFORM THE ECONOMY OF ORISSA INTO A SELF-GENERATING ONE, ENABLING THE BALANCE OF THE MASTER PLAN TO BE LARGELY EXECUTED WITH THE RESOURCES GENERATED FROM THE TIKERPARA POWER PROJECT.

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ORISSA AND ITS PROBLEMS

Orissa mirrors the paradox of all backward areas—poverty amidst potential plenty. Orissa has untold wealth of natural resources—land, forests, water, minerals, a long sea coast, and a population of 17·57 millions. Yet it is the poorest and most backward State of India. Any plan for the development of these vast natural resources, which will help transform poverty into plenty in the State of Orissa, may well serve as a model for other similarly situated areas in India and elsewhere in the world.

Flood and Droughts—

For centuries, Orissa has been haunted by the twin spectre of flood and drought, and of these the latter has been the most terrible. The distribution of rainfall and consequently of the river supplies through the year vary within wide limits. There is too much water during the rains and too little during the dry part of the year, with the result that Orissa continues to suffer devastation by floods and starvation, misery and disease from droughts. Terrible famines occurred in the 14th, 15th and 16th centuries. In the memorable famine of 1770 people were reported to have been dying by hundreds and thousands. Nearly a century later, came the great Orissa famine of 1865-66. The rainfall in 1865 was scanty and ceased prematurely. Food crops failed and it was estimated that nearly one million people died in the district of Cuttack alone. In the district of Puri nearly 40 per cent of the population perished. Then followed the flood of 1866. Crops and property were destroyed and what the drought had spared was engulfed in the wide flood waters.

Only two years ago in 1961, serious flood damage occurred over 3,600 square miles of area ; 650,000 acres of crops were damaged and 19 human lives lost. The expenditure on relief alone was Rs. 5·77 crores.

Severe drought conditions prevailed in most districts of Orissa in 1962 due to failure of rains. Twenty-five per cent of the total cultivated area of the State was affected. The estimated loss of *Kharif* crop was more than Rs. 60 crores.

FLOOD CONTROL AND IRRIGATION ARE: THEREFORE :
THE TWO BASIC NEEDS OF ORISSA.

GENERAL FEATURES

Physical (Plate I)

The State of Orissa is situated in the north-eastern section of the Indian Peninsula and extends over an area of 60,136 square miles. It is a maritime State with a coastline of 250 miles along the Bay of Bengal. It has a common boundary with West Bengal in the north-east, Bihar in the north, Madhya Pradesh in the west and Andhra Pradesh in the south-west. It can be divided into four main physical regions—the northern plateau, the central table-land, the Eastern Ghats and the coastal plain.

Climate

The mean maximum temperature is 91° F (33° C), rising to 101° F in April and May, and falling to 80° F in January. The mean minimum temperature is 70° F (21° C). The

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average rainfall is 59 inches. About 81 per cent of this rainfall is received during the period June—September mainly from the Bay of Bengal branch of the south-west monsoon.

Population

According to the 1961 Census the population of Orissa has gone up to 17·57 millions with a density per square mile of 292. The increase in the total population during the decade 1951—61 was 1·99 per cent per annum. The coastal district of Cuttack has the heaviest density of population which is over 600 per square mile. Adibasis, Scheduled Castes and other backward classes constitute nearly 67 per cent of the State's population, the Adibasi population accounting for nearly 24 per cent.

Living Standards

The *per capita* income of Orissa during 1960-61 was Rs. 212 against the All-India average of Rs. 330.

Natural Resources

The most important of Orissa's natural resources are its land, forests, water, minerals and marine wealth.

Land and Agriculture

The total area of the State is about 38·4 million acres, of which about 36 per cent was cultivated in 1955-56. Orissa's main weakness stems from its poor agricultural base, archaic cultivation, vagaries of the monsoon and damage due to recurring floods, all resulting in low yields and uncertain harvests. The yield of rice, which is Orissa's chief crop, accounting for over 63 per cent of the total cropped area, is the lowest in India—514 lbs. per acre compared with 1,255 lbs. in Madras and 806 lbs. for India as a whole. This can easily be doubled or more if adequate irrigation facilities can be assured.

Eight out of every ten Oriyas subsist on agriculture.

Forests

Next to Madhya Pradesh, Orissa has the largest forest area amongst the States of the Indian Union covering 25,331 square miles or nearly 41·01 per cent of the total land area. Apart from their effect on climate and their role in preventing soil erosion, fosests provide valuable raw materials for industry and are an important source of revenue to the State.

Water

Orissa has enormous water wealth in its many rivers which are fairly evenly scattered over the State. Between them they carry a mean annual flow of nearly 121 million acre feet or roughly one-tenth of the total runoff of the entire river system of India. The runoff is, however, very unevenly distributed through the months. There is either too much water during the monsoon period resulting in heavy floods, or too little during the dry season, resulting in failure of crops.

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MAP OF ORISSA STATE

SHOWING MINERALS, RIVERS, IRRIGATION & NAVIGATION, CANALS & POWER STATIONS

SCALE 1" = 48 MILES

LEGEND

IRON ORE ●
MANGANES ■
LIME STONE ◘
DOLAMITE ◗
CHROMITE
COAL
MONAZITE

GOLD ◐
LEAD
ASBESTOS
STEATITE
COPPER ◊
MICA
SALT ⊗

BAUXITE ○
FIRECLAY
CHINACLY
QUARZITE ★
KYANITE ⊖
GRAPHITE ◠

220 K. V. TRANSMISSION LINE
POWER STATION LARGE
POWER STATION MEDIUM
POWER STATION SMALL
THERMAL POWER STATION
PUMPING STATION
NAVIGATION CANAL EXISTING
NAVIGATION CANAL PROPOSED
NUN-NAVIGABLE CANAL
RIVER
RESERVOIR
DAM
BARRAGE
EXISTING RAILWAY
PROPOSED RAILWAY
PROPOSED DUBLING RAILWAY

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TABLE I
RIVERS OF ORISSA

River	Catchment area (square mile)	Mean annual rainfall (inches)	Mean annual runoff (inches)	Mean annual runoff (m. a. ft.)	Maximum flood discharge cusecs	Minimum* dry weather discharge (cusecs)
I. Mahanadi (Naraj) ..	51,270	57·36	27·51	75·25	1,580,000 2,700,000 (*a*)	1,500
Brahmani ..	14,000	58·93	27·45	20·50	800,000	300
Baitarani ..	4,000	58·93	27·45	5·86	500,000	100
Total ..	69,270			101·61		
II. Rushikulya ..	3,072	43·50	8·47	1·43	300,000	Nil
Burabalanga ..	1,736	56·28	22·55	2·09	200,000	50
Subarnrekha ..	7,047	56·28	22·55	8·46	600,000	100
Total	11,855			11·98		
III. Indravati † ..	1,040	74	40·09	2·27	240,000	100
Kolab (Sabari) † ..	1,200	70	33·02	2·12	260,000	120
Sileru † ..	1,855	70	38·02	3·28	323,000	190
Total ..	4,095			7·67		
Grand Total ..	85,220			121·26		

Minerals (Plate II)

Orissa has enormous mineral wealth. The resources so far known are considerable and diverse, and the potential mineral occurrences give promise of discovery of large deposits. Moreover, several occurrences are yet to be explored and about a third of the State remains to be surveyed by the Geological Survey of India. Taking all these facts together, Orissa would have perhaps the largest mineral resources among all the minerals bearing States of India. It has iron ore, manganese ore, coal, dolomite, limestone, chromite china clay, graphite and fire clay. The present estimate places the iron ore reserves at about 10,000 million tons, and of coal at about 40,000 million tons, both nearly 50 per cent of All-India estimates.

Fisheries

Fisheries, both inland and marine, occupy an important place in Orissa's economy. 35,000 persons have fishing as their principal means of livelihood in the Chilika lake (450 square miles in area) where nealy 3,500 tons of fish are raised each year. The yield per acre from the Chilika lake is 75 to 100 lbs., one of the highest in the world for brackish water fisheries.

(*a*) Accepted for design.

* Figures of minimum dry weather discharge are for the natural flow of the rivers before any storage dam is constructed on any of them.

† Above lowest dam sites in Orissa territory. (Indravati, Kolab and Sileru are tributaries of the Godavari river.)

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Orissa has a 250 mile long coastline which is covered in many parts by river-mouths and estuaries. On an average the State produces a total of 23,000 to 25,000 tons of fish per year, of which about a third is sea fish and the remainder estuarine and fresh water fish from all the inland sources. Fisheries contributed roughly Rs. 1·76 crores to the State income in 1956-57. Considering that Orissa is a maritime State, the share of fisheries in the State income is low. There are hardly any fish-based industries in the State.

Coastal fishing is confined to a narrow belt of 3 or 4 miles over a relatively short stretch of the coast. On account of lack of proper berthing, landing and other harbour facilities, no off-shore fishing has developed in the State. It would be possible and profitable to use a large number of bigger boats and operate trawlers if proper berthing and harbour facilities were developed in suitable locations along the coast. There are rich fishing grounds in the sea off the coast of Orissa.

Industries

Orissa, one of the richest States in India in land, forests, minerals, water and marine resources, has remained industrially backward because of the lack of electrical power and adequate transport and communication facilities. The total power installed in the State was only 300 KW in 1945.

One sugar mill, a glass factory, a soap works, a few oil mills and a number of rice mills, comprised the entire industry of Orissa in 1945.

The First and Second Five-Year Plans have, however provided a much needed impetus to the industrial development of the State with power becoming available from the Hirakud and the Machkund hydro-electric projects. The Rourkela Steel Plant with an annual production capacity of one million tons of ingot steel, was put up during the Second Five-Year Plan. A fertiliser factory, with an annual capacity of 50,000 tons of nitro-limestone, has been set up in the immediate neighbourhood of the Steel Plant to utilise the by-products of the steel works as raw materials. Ferro-manganese plants have been set up at Joda and Rayagada. An Aluminium Smelter, with an annual capacity of 20,000 tons, has been set up near the Hirakud Power Station. Orissa has 2 large cotton mills near Cuttack, three sugar factories at Aska, Rayagada and Singhpur Road, with three more coming up ; and three paper mills at Brajarajnagar in Sambalpur district, at Chaudwar in Cuttack district, and near Rayagada in Koraput district.

Transport and Communications

Inadequate transport and communication facilities have been a major barrier to the economic and industrial development of Orissa. As against an All-India average of 31 miles of rail track for every 1,000 square miles of territory, the State has only 14 miles. Similarly, for every 1,000 square miles, Orissa has 53 miles of surfaced roads compared to 261 miles for Madras, 124 miles for Andhra, and 102 miles for West Bengal.

Ports

Despite an extensive coastline, Orissa will be having by the end of the Third Five-Year Plan one port—the Paradeep Port—only recently taken up for construction which will

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be ready by end of 1965 and will handle 2 million tons of iron ore by 1965 and may be extended later on to handle 10 to 15 million tons per year.

Inland Navigation

Orissa has a net work of small navigable canals—the Taladanda, the Kendrapara, the High Level, the Coastal and the Jajpur canals, totalling 154 miles in length, which provide the cheapest means of transport in the coastal areas of Orissa. These have been somewhat improved after the completion of the Hirakud Dam Project and the Delta Irrigation Scheme.

PLANNING FOR PROSPERITY

From many points of view, Orissa potentially the richest, is probably the most backward region in the country. The poorer the region, the more urgent is the need for accelerating growth, but the greater also is the difficulty in raising internal resources for investment. This is Orissa's dilemma. Given these resources and the will to achieve, Orissa is destined to be the most industrially advanced State in India.

The plan provisions during the First, Second and Third Five-Year Plans and the expenditure during the First and Second Plans are given below:—

TABLE 2

PLAN OUTLAYS AND EXPENDITURE

(Crores of rupees)

	All-India Plan			Orissa Plan					
	Outlay	Total of State Plans	Central assistance to States	Outlay	Expenditure	State resouces	Central assistance	Per cent of total of State plans col. 5/ col. 3.	Per cent of total Central assistance col. 8/ col. 4.
1	2	3	4	5	6	7	8	9	10
First Plan (1951—56).	1,960	898	350	74·5*	68·1*	8·0	60·1	8·3	17·2
Second Plan (1956—61).	4,600	2,043	1,038	100·0*	84·0*	18·3	65·7	4·9	6·3
Third Plan (1961—66).	7,500	4,020	2,375	160·0*	104·0 (*a*)	31·3	128·7 @	3·98	5·4
				220	227 (*b*)			5·6	7·5

* Includes outlay and expenditure on Hirakud, but excludes all Centrally-sponsored schemes.

(*a*) Expenditure of first three years including current year's anticipated outlay.

(*b*) Anticipated total to end of Third Plan.

@ On the basis of the overall Central assistance of Rs. 2,375 crores available for all States.

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Orissa has 4·02 per cent population and 4·96 per cent area of All-India figures. It has 10 per cent water wealth and almost 40 to 50 per cent tonnage mineral wealth of the total water and mineral wealth of India.

Any plan for the overall development of this extremely poor but potentially the richest State in India must give first consideration to the solution of the problems of flood and drought. Conservations of flood waters during the monsoon through storage and their utilisation through regulated releases during the dry parts of the year for purposes of flood control, irrigation, power generation, navigation, fish culture, tourism and other facilities must, therefore, constitute the core of the plan. This coupled with the accelarated pace of development of industries based on the immense water resources and mineral wealth of the State and consequent on large-scale increase in agriculture, power and transport facilities under the Plan, will need proportionately much greater outlay in the Fourth and subsequent Plans than has been provided for Orissa in the Third and earlier Plans.

THE MAY 1945—PLAN

In May 1945, Dr. A. N. Khosla, then Chairman, Central Waterways, Irrigation and Navigation Commission (Central Water and Power Commission) and now Governor of Orissa, conceived the Plan for the Unified Development of the Mahanadi Basin as a first step in the overall integrated development of the river basins of Orissa. This Plan envisaged the construction of three storage dams on the Mahanadi at Hirakud, Tikerpara and Naraj, for securing complete control of the Mahanadi floods and for developing power, irrigation, navigation, pisciculture and other facilities.

The construction of the Hirakud Dam and Power Plant was undertaken in 1949-50 immediately after the surveys and investigations were completed and the project report was prepared and approved. This constituted the first stage in the plan of basin-wide development of the Mahanadi river. It was completed in 1956 and inaugurated in 1957. The project for the construction of the Naraj Dam was later substituted by that of a diversion weir at Mundali nearby, which is now in progress.

The project for the construction of the Tikerpara Dam, which constitutes the Core of the May 1963 Master Plan, is actively under investigation and preparation.

THE MAY 1963—MASTER PLAN

The May 1963 Master Plan for Orissa is a continuation of the May 1945 Plan and has been conceived in the background of the history of droughts in the 14th, 15th, 16th and 18th centuries and the recurring devastating floods, of the more recent flood of 1961 and the drought of 1962 with its estimated loss of crops worth over 60 crores of rupees, and the continuing miserably low standard of living of the people. It is the Plan for the total development of Orissa for agriculture, power, transport, industry and social services through the Integrated Development of its River Basins. The Development for power includes hydro power from stream flows as well as thermal power from Talcher coals and/or from middlings at the coal washeries in Bihar-Bengal coal fields.

The Master Plan will provide all the essential requisites for the development of agriculture, mining and industry, which constitute the base for all economic advance and

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defence build-up. These requisites are protection from floods, water for irrigation, industry and domestic use, electric power for factory and farm ; water and other transport facilities, lakes and reservoirs for pisciculture, recreation, tourism etc. The present exposition of this Plan deals with these aspects of development only and that in broad terms. The details will have to be filled in after due investigation, by the appropriate departments of the State or States concerned.

The development of various industrial complexes made possible by the above developments will be dealt with separately.

The Master Plan can be considered in two parts:

Part I—River Valley Projects dealing with all developments pertaining to water, which includes flood control, irrigation, hydro-electric power, inland waterways for navigation, fish culture, tourism and a possible seaport and harbour at the Chilika lake.

Part II—Thermal Power Projects based on Talcher coals or, alternatively, also on middlings from washeries in the Bihar-Bengal region and the phasing of thermal power development in step with the stages of development of the river valley projects, and also the economics thereof.

The salient features of Part I Projects are summarised in Table 3 and those of Part II Projects in Table 4.

For Part I—River Valley Projects—the programme of development is envisaged under six groups A, B, C, D, E and F.

For Part II——Thermal Power Projects—the programme of development for optimum results is tentatively phased in Table 4 to correspond to and dovetail into the programme of development under groups A, B, C, D and E of River Valley Projects. This assumes that the necessary resources will become available at each stage. This phasing can be altered to suit availability of funds and regional power needs.

Priorities

The river valley projects have necessarily to be developed first. These, besides power provide, firstly, the basic needs of Orissa, namely, flood control, irrigation and fish culture and incidentally also navigation, tourism, etc.; and, secondly, power at a much lower units cost than thermal power whether developed with cheap coals at Talcher or with middlings at the washeries (*see* last columns of Tables 3 and 4).

A Multi-State Plan

The 1963 Master Plan is not a plan for Orissa only. It is essentially a Multi-State Plan for the six Eastern States of India. In respect of power, it is a Plan for the Eastern Region comprising Orissa, West Bengal, Bihar, Madhya Pradesh, Andhra Pradesh, Uttar Pradesh and possibly also Maharashtra. In respect of Irrigation, it is a Plan for Orissa, West Bengal and Andhra Pradesh.

The pace and pattern of development of power will be determined, besides needs of Orissa, by the combined needs of the Region as a whole, and also by consideration at each Stage, of the relative proportions of hydro and thermal power generation to ensure maximum utilisation of installed capacity (both hydro and thermal) and minimum unit generation cost.

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As regards irrigation, it appears possible to extend irrigation from the Mahanadi water stored at the Tikerpara Dam to a million or more acres of land in Midnapur district in West Bengal, extending from Orissa border to the Rupnarain river and Haldia Port, and to a similar acreage (if physically within limits of command) in Andhra Pradesh extending from the Orissa border to Visakhapatnam Port.

Participation of West Bengal and Andhra Pradesh Government

As to whether West Bengal and Andhra Pradesh would like to share in the stored waters at Tikerpara for purposes of irrigation, a decision will have to be taken at an early stage, as that will vitally effect the scope of the project and the design and layout of its channels. Providing irrigation water to agricultural areas in these States and water for demestic and industrial use to the ports of Haldia and Visakhapatnam will need substantial enlargement of the main canals on the two banks and adjustment of their full supply levels to feed these additional supplies.

Haldia and Visakhapatnam Ports

There is also the possibility of providing reliable water-supply from this source for the port and town of Haldia, as also, for the port and town of Visakhapatnam, including all future extensions. This latter is under investigation.

Navigation

Regarding navigation, the main irrigation canals will be navigable. These and the various reservoirs will provide about 1,000 miles of navigable waterways traversing through Orissa and, if the Governments of West Bengal and Andhra Pradesh agree, 80 miles in West Bengal and 150 miles in Andhra Pradesh, terminating at Haldia Port in West Bengal and Visakhapatnam Port in Andhra Pradesh. The Paradeep Port under construction, the proposed Santrapur Port on the Chilka Lake, the proposed Haldia Port and the Visakhapatnam Port will all form part of this inland waterways system linked to each other through this network of irrigation-*cum*-navigation canals.

PART I—RIVER VALLEY PROJECTS

The following are the six groups of river valley projects. (*See* Table 3 and Plate III)

GROUP (A)—This includes projects, which were completed during the Second Plan, namely, the Hirakud Dam Projects for flood control, irrigation and hydro-electric power (completed 1956), and its extension, the Chiplima Power Canal and power plant (completed 1963) ; and the Machkund Dam Project for hydro-electric power (completed 1959) ; and projects approved and taken up for construction, namely, Balimela Dam Project for irrigation and generation of hydro-electric power. These between them, will provide irrigation for 2·53 million acres of crops and have an installed capacity of 0·95 million K.W at 30 per cent load factor.

GROUP (B)—This includes the Tikerpara-Gania Project—the Core Project of the May 1963 Master Plan and the small Tikra Project. The former will provide complete control of the Mahanadi floods in the delta, irrigation to nearly 6·3 million acres of new area (*Kharif*

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MAP OF
ORISSA STATE
SHOWING RIVERS, IRRIGATION & NAVIGATION CANALS AREAS TO BE IRRIGATED, POWER STATIONS AND TRUNK TRANSMISSION LINES

SCALE 0 8 16 32 64 MILES

LEGEND

220 K. V. TRANSMISSION LINE
POWER STATION, LARGE
POWER STATION, MEDIUM
POWER STATION, SMALL
THERMAL POWER STATION
NAVIGABLE CANAL EXISTING
NAVIGABLE CANAL PROPOSED
NON-NAVIGABLE CANAL
RIVER
PUMPING STATION
RESERVOIR
DAM
BARRAGE
EXISTING RAILWAY
PROPOSED RAILWAY
PROPOSED DOUBLING RAILWAY
EXISTING IRRIGATED AREA
PROPOSED IRRIGATED AREA

plus *Rabi*), hydro-electric power generation to the tune of 4·29 million K.W. at 30 per cent load factor, and a net work of navigable canals about 750 miles in length, extending from one end of Orissa to the other, and, if Andhra Pradesh and West Bengal participate, also to Visakhapatnam and Haldia Ports. The Tikra Dam Project, which will ultimately become a part of the Barkot Dam Project under Group (D), is essential for water-supply to the Talcher Thermal Station and the coal based industrial complex to be established between Talcher and Tikerpara. This will later provide the navigation link between Talcher and the Mahanadi river and from there to the Paradeep Port.

GROUP (C)—This includes the Indravati and the Upper Kolab Projects in the districts of Koraput and Kalahandi. These will irrigate 880,000 acres of new areas and will have an installed capacity of 1·16 million K.W. of hydro-electric power at 30 per cent load factor. Of these, the Indravati Project appears to be the most attractive.

GROUP (D)—This includes the Barkot Dam Project on the Brahmani river—the second key project of the Plan, and the Lower Kolab Project in the Kolab tributary of the Sabari river. These between them will irrigate 1·053 million acres and have an installed capacity of 1·42 million K.W. (30 per cent load factor). The Barkot Project will, in addition, provide flood control of the Brahmani river and a navigable waterway connecting the Rourkela Steel Plant and the Bonai iron-ore deposits with Talcher coal field and the Paradeep and the proposed Santrapur Ports. It will also provide a navigation link to Tikerpara reservoir through the Barkot-Tikra-Rampur link and further on to Chiplima and to Hirakud reservoir through the Rampur-Deogaon link.

GROUP (E)—This includes the Bhimkund Project on the Baitarani River. This will provide flood control of the Baitarani river and an installed capacity of 624,000 K.W. (at 30 per cent load factor). It will also provide a small amount of additional irrigation, the bulk of area under command having already been taken care of under the Tikerpara-Gania Project. A Project Report for this has already been prepared, but this project has **been kept lowest in order of priority, and can be taken up only if the need for flood control and additional power provides the justification.**

GROUP (F)—This includes projects on the many tributaries of the rivers of Orissa. Of these, the ones on the Mahanadi appear to possess considerable potential for irrigation and to a smaller extent for power. These projects have not been examined even in a preliminary way. Some of these may be taken up as medium irrigation projects at various stages of development of projects under Groups, B, C and D.

Apart from the Tikkerpara Project, the survey, investigations and preparation of Project Report relating to which are in an advanced stage, and the Bhimkund Project, the report on which has already been prepared, the planning for the other projects is based mainly on available hydrological data, printed topographical maps, site inspections and limited site investigations. The figures of runoff are a fairly close estimate. The figures of cost are in the nature of the best guess possible under the circumstances, but believed to be fairly representative. Those for Tikkerpara Power Project are firm figures as a result of detailed designs and estimates.

Table 3 gives salient features of each group and of each project in that group.

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PLAN FOR THE INTEGRATED DEVELOPMET

Group Number	Name of the Project	Catchment area (Square miles)	Area Sub-merge (acres)	Mean annual rainfall (inches)	Mean annual runoff million (acre feet)	Storage million acre feet		Mean regulated flow (Cusecs)		
						Gross	Live	Total	For Irrigation	For Power
A	HIRAKUD ..	32,750	1,81,000	56·08	48·20	6·60	4·72	13,360	..	10,000
	Hirakud Irrigation ..	..	..	..	..	..	..	..	3,360	..
	Delta Irrigation ..	..	..	..	..	..	..	..	8,820	..
	MACHKUND ..	755 * †	22,500	70·00	* + 1·34	0·79	0·73	* + 1,600	..	1,600
	BALIMELA ..	1,855	44,300	70·00	3·28	3·09	2·30	2,100	2,100	2,100
	Total ..	34,605	2,47,800	..	51·48	10·48	7·75	15,460	14,280	..
B	TIKERPARA ..	* + 48,000	6,00,000	57·36	70·50	47·00	38·00	55,000	..	55,000
	GANIA ..	48,705	20,000	57·36	71·54	0·40	0·10	55,800	23,210	+ 12,200
	Tulasipur ..	..	..	..	..	..	..	..	+ 4,000(*b*)	..
	Tangi ..	..	..	..	..	..	..	..	..	29,160
	TIKRA-BARKOT PROJECT	512	34,000	58·93	0·75	1·90	1·15	.. 700	700	700
	Total ..	49,217	6,54,000	..	72·29	49·30	39·25	56,500	23,910 + 4,000(*b*)	..
C	INDRABATI ..	1,040	29,400	74·00	2·27	2·35	1·55	2,775	2,775	2,775
	UPPER KOLAB ..	618*	45,000	70·00	1·09*	1·15	1·08	1,400	1,400	1,400
	DEGAON-RMAPUR ..	..	..	..	..	..	..	*10,000	..	*10,000
	Total ..	1,040	74,400	..	2·27	3·50	2·63	4,175	4,175	..
D	BARKOT ..	8,848	1,48,000	58·93	12·95	5·95	3·10	13,450	3,775	12,930
	LOWER KOLAB ..	1,250 + 913	42,500	70·00	4·15	2·91	2·00	1,750	680	1,750
	Total ..	11,006	1,90,500	..	17·10	8·86	5·10	15,200	4,455	..
E	BHIMKUND ..	2,370	80,000	58·93	3·48	3·40	3·00	3,200	220	3,200
	Total ..	2,370	80,000	58·93	3·48	3·40	3·00	3,200	220	3,200
	Grand Total ..	98,238	12,46,700	..	146·62	75·54	57·73	94,535	47,040 + 4,000	..
F	Bheden (Mahanadi) ..	575	N. A.	37·36	0·85					
	Ong (Mahanadi) ..	361	N. A.	57·36	0·53					
	Tel (Mahanadi) ..	886	N. A.	57·36	1·30					
	Salki (Mahanadi) ..	315	N. A.	57·36	0·46					
	Bagh (Mahanadi) ..	350	N. A.	57·36	0·51					
	Ordai (Baitarani) ..	205	N. A.	45·56	1·63					
	Khairi Bhandan Deo (Baitarani).	316	N. A.	45·56	2·52					
	Burhabalang ..	288	N. A.	56·28	0·35					
	Subarnarekha ..	3,677	N. A.	56·28	6·81					
	Khandakai (Subarnarekha) ..	435	N. A.	56·28	0·58					

NOTE

\+ Not considered for group total

* Not considered for group total

** Figures are for Hirakud plus Chiplima

(*a*) Only 3,360 C. S. of Hirakud has been included in the Grand Tota',

(*b*) Figures in bracket are for Andhra Pradesh and West Bengal. Actually these may be 2,000,000 acres or more but the figures of 800,000 is retained as cost figures have been worked on that basis. The total acreage may thus come to 8,994,000+2,000,000=10,994,000 acres say 11 million acres.

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3

OF THE RIVER BASINS OF ORISSA (MAY 1963)

Area to be irrigated (thousands acres)			Power generation				Cost of projects (Rupees in crores)				Unit cost		
Kharif	Rabi	Total	Average head in feet.	* 100% L. F. M. W.	* 30% L. F. or installed capacity M. W.	Units generated in million K. W. H.	Total	Flood control	Irrigation	Power	Per acre irrigated in rupees	Per unit generated at bus bars in naya Paisa 1 Naya Paisa = 2·08 U. S. Mills. Hydro	System Hydro and Thermal (from last column. Table 4)*
..	..	..	**179·50	**128	*427·5	**1,120	**129·34		..	64·68	..	3·76	
380	220	600	..	..	..	..	..		19·66	..	328	..	
964	578	1,542	..	..	..	..	..		45·00	..	292	..	
..	..	..	840	96	114·75	310	6·00		..	6·00	..	1·26	2·38
				35·3	42·20								
240	144	384	920	138	480·00	1,210	45·52	..	12·60	32·92	328	1·78	
1,584	942	2,526	..	301·3	949·7	2,640	180·86	..	77·26	103·60	306	..	
..	..	..	210	825	2,750	7,230	195·00	35·00	5·00	155·00 (135)	..	1·38	
					(2,000)		(175)					1·15	
2,708 (+500)	1,625 (+300)	4,333 (+800)	..	..	..	..	(*d*)246·22		133·07	..	308	..	
			96	83·6	279	733	..	..	..	18·31	..	1·63	1·87
..	..	..	166	346	1,250	3,025	..	..	..	94·84	..	2·04	
88	53	141	163	5·2	6	46	8·09	..	6·58	1·51	466	2·14	
2,796 (*b*) (+500)	1,678(*b*) (+300)	4,474 (*b*) (+800)	..	1,259·8	4,285	11,034	449·31	35·00	144·65	269·66	323	..	
350	210	560	11·80	234	780	2,050	61·02	..	17·52	43·50	313	1·38	1·95
200	120	320	740	79	264	693	25·25	..	9·25	16·00	289	1·50	
			50	36	120	..	12·00	..	..	18·00	..	1·41	
550	330	880	..	349	1,164	2,743	104·27	..	26·77	70·50	..	..	
[illegible]58	335	893	..	315	1,053	2760*	154·61	..	63·60	91·01	713	2·14	2·07
100	60	160	883	110·4	367·5	965	33·11	..	7·00	26·11	4·37	1·76	
658	395	1.053	..	425·4	1,420·5	3,725	187·72	..	70·60	117·12	670	..	
38	23	61	870	182·6	624	1,600	64·16	..	1·90	62·26	312	2·53	
38	23	61	..	182·6	624	1,600	64·16	..	1·90	62·26	312	2·53	2·02
5,626 (*b*) (+500)	3,368(*b*) (+300)	8,994 (*b*) (+800)	..	2,518·10	8,443·2	21,742	986·32	35·00	321·18	630·14	358	..	

NAVIGABLE WATER WAYS MILES

	Canal	Reservoir	Total
Total Plan—			
Orissa	800	200	1,230
West Bengal	80	..	
Andhra	150	..	
Tikerpara—			
Orissa	465	100	795
West Bengal	80	..	
Andhra	150	..	
Gania Project –			

4,000 cusecs of mean annual flow equivalent to 2·92 m.a.f. have been allocated half to Andhra Pradesh and half to West Bengal to do 4,00,000 acres of annual irrigation in each State. This may go up to 10,000 cusecs to do 2,000,000 acres in the two States instead of 800,000 but the figures of 4,000 cusecs in the table are not changed as cost figures have been worked on these basis.

(d) Split up of cost of Group B Projects..

		Tikerpara	Gania
Dam and appurtenant works.	Power ..	120·14	12·80
	Irrigation ..		3·20
	Flood Control ..	..	..
Water conductor system		3·83	5·34
Power-house and Switch yard.	Civil works ..	20·00	9·94
	Electrical units	24·00	23·00
	Switch gear	7·00	5·61
Canals and Fore bays.	Power ..	..	55·46
	Irrigation ..	..	129·87
	Total ..	174·97	246·22

* Coal at Rs. 20 per tonne.

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TABLE

PLAN FOR THE INTEGRATED DEVELOPMENT

POWER

PHASE	NAME OF STATION	HYDRO									
		INSTALLED CAPACITY				Available peaking capacity (MW).	Firm power at 100 % L. F. (MW).	Units generated 10^6 KWH	Capital cost power portion (Rs. crores).	Annual charges (Rs. Crores) (a).	Cost per unit generated (n.P.)
		No.	Size (MW)	Total new installation (MW).	Total installed at station (MW)						
I	GROUP A										
	HIRAKUD ..	4 2	37·5 24·0	198							
	CHIPLIMA ..	3	24·0	72	72						
	HIRAKUD 7TH UNIT	1	37·5	37·5	235·5	427·5	128	1,120	64·68	4·20	3·76
	CHIPLIMA NEW POWER-HOUSE.	5	24·0	120·0	120·0						
	MACHKUND ..	3 3	17·0 21·25	114·75	114·75	42·20	35·3	310	6·0	0·39	1·26
	BALIMELA ..	6	60·0	360·00	360·0	360·00	138·0	1,210	29·33	1·91	1·50
					902·25	829·7					
II	GROUP A										
	HIRAKUD SYSTEM..				427·5	427·5	128	1,120	64·68	4·2	3·76
	MACHKUND ..				114·75	42·2	35·3	310	6·0	0·39	1·26
	BALIMELA ..	2	60	120	480	480	138	1,210	32·92	2·14	1·78
	GROUP B										
	TIKERPARA ..	8	125	1,000	1,000	1,000	825	7,230	115·0	6·8	0·945
	TULSIPUR ..	3	93	279	279	279	83·6	733	18·31	1·2	1·63
	TANGI ..	10	125	1,250	1,250	1,250	346	3,025	94·84	6·16	2·04
	TIKRA ..	1	6	6	6	6	5·25	46	1·51	0·098	2·14
					3,557·25	3,484·7					
III	GROUP A										
	HIRAKUD SYSTEM..				427·5	427·5	128	1,120	64·68	4·2	3·78
	MACHKUND ..				114·75	42·2	35·3	310	6·0	0·39	1·26
	BALIMELA ..				480	480	138	1,210	32·92	2·14	1·78
	GROUP B										
	TIKERPARA ..	8	125								
	TULSIPUR ..	3	93		279	279	83·6	733	18·31	1·2	1·63
	TANGI ..	10	125		1,250	1,250	3·46	30·25	94·84	6·16	2·04
	TIKRA ..	1	6		6	6	5·25	46	1·51	0·098	2·14
	GROUP C										
	TIKERAPARA .. INDRAVATI .. UPPER KOLAB .. DEOGAON ..	8 10 4 4	125 78 66 30	1,000 780 264 120	2,000 780 264 120	2,000 780 264 120	825 234 79 36	7,230 2,050 693 311	135·0 43·5 16·0 18·0	8·29 2·83 1·045 1·04	1·15 1·38 1·5 3·34
					5,721·25	5,646					

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4

OF RIVER BASINS OF ORISSA (MAY 1963)

DEVELOPMENT

	THERMAL												INTEGRATED SYSTEM HYDRO AND THERMAL						
NAME OF STATION	INSTALLED CAPACITY (1,000 K.W.)						Units generated 10^6 KWH	Capital cost (Rs. crores)	ANNUAL CHARGES (Rs. crores)			Cost per unit generated	CAPACITY (1,000 KW.)			Units generated 10^6 KWH	Capital cost (Rs. Crores) (d)	Annual charges (Rs. crores) (a).	Generated cost per Unit nP.
	No.	Size (MW.)	Total new installation (MW.)	Total installation (MW.)	Total less 8 % for Auxiliaries.	Firm power (MW.) (c).			Fixed charges (a)	Coal (b)	Total		Total installed capacity.	Peaking exclusive of 20 % reserve.	Firm Power (c)				
TALCHER	4	62·5	250																
	2	125	250	500	460	414	3,630	45·00	3·20	5·24	8·44	2·33							
				500	460		3,630						1,402·25	1,032	714	6,260	144·97	15·21	2·38
	4	62·5																	
	2	125																	
TALCHER OR THERMAL STATION IN BIHAR-BENGAL WASHERIES BASED ON MIDDLINGS.	4	250	1,000	1,500	1,380	1,170	10,280	125	9·12	14·72	23·84	2·32							
				1,500	1,380		10,280						5,057·25	3,892	2,720	23,880	485·26	44·628	1·87
	4	62·5																	
	2	125																	
	4	250																	
TALCHER OR THERMAL STATION IN BIHAR-BENGAL WASHERIES BASED ON MIDDLINGS.	5	500	2,500	4,000	3,680	3,250	28,500	285	20·8	41·0	61·80	2·18							
				4,000	3,680		28,500						9,601·25	7,636	5,160	45,260	715·76	88·067	1·95

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TABLE

POWER

PHASE	NAME OF STATION	HYDRO									
		INSTALLED CAPACITY				Available peaking capacity (MW).	Firm power at 100 % L. F. (MW).	Units generated 10[6] KWH	Capital cost power portion (Rs. Crores).	Annual charges (Rs. Crores) (a).	Cost per unit generated (nP.)
		No.	Size (MW)	Total new installation (MW).	Total installed at station (MW).						
	GROUP A										
	HIRAKUD SYSTEM..				427·5	4,27·5	128	1,120	64·68	4·2	3·78
	MACHKUND ..				114·75	42·2	35·3	310	6·0	0·39	1·26
	BALIMELA ..				480	480	138	1,210	32·92	2·14	1·78
	GROUP B										
	TIKERPARA ..	16	125				825	7,230			
	TULSIPUR ..	3	93		279	279	83·6	733	18·31	1·2	1·63
	TANGI ..	10	125		1,250	1,250	346	3,025	94·84	6·16	2·04
	TIKRA ..	1	6		6	6	5·25	46	1·51	0·098	2·14
	GROUP C										
	TIKERPARA ..	6	125	750	2,750	2,750	825	7,230	155·0	9·92	1·38
	INDRAVATI ..	10	78		780	780	234	2,050	43·5	2·83	1·38
	UPPERKOLAB ..	4	66		264	264	7	693	16·0	1·045	1·5
	DEOGAON ..	4	30		120	120	36	311	18	1·04	3·34
	GROUP D										
	Barkote										
IV	LEFT NEAR DAM ..	2	35·5	71							
	LEFT DAMSAL ..	2	45	90							
	RAMPUR ..	5	40	200							
	TIKERPARA ..	2	125	250							
	TANGI ..	2	125	250							
	TIKRA RIGHT, NEAR DAM.	2	38	76							
	RASOL ..	2	28	56							
	TIGIRIA	1	28	28							
	ATHGARH ..	1	32								
	BARKOT TOTAL ..				1,053	1,053	315	2,760	91·01	5·92	2·14
	Lower Kolab										
	POWER-HOUSE I ..	1	37·5	37·5							
	POWER-HOUSE II ..	3	62·0	186							
	POWER-HOUSE III ..	2	72·0	144							
	LOWER KOLAB TOTAL				3,67 5	3,67·5	110·35	965	26·11	1·695	1·76
					7,891·75	7,812					

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DEVELOPMENT—*contd*

NAME OF STATION	THERMAL: INSTALLED CAPACITY (1,000 KW.): No.	Size (MW)	Total new installation (MW)	Total installation (MW)	Total less 8% for Auxiliaries.	Firm power (MW) (c)	Units generated 10^6 KWH	Capital cost (Rs Crores)	ANNUAL CHARGES (Rs. Crores): Fixed charges (a)	Coal (b)	Total	Cost per unit generated	INTEGRATED SYSTEM HYDRO AND THERMAL: CAPACITY (1,000 KW): Total installed capacity.	Peaking exclusive of 20% reserve.	Firm Power (c)	Units generated 10^6 KWH	Capital cost (Rs. Crores) (d)	Annual charges (Rs. Crores) (a).	Generated cost per Unit (nP.)
	4	62·5																	
	2	125																	
	4	250																	
	5	500																	
TALCHER OR THERMAL STATION IN BIHAR-BENGAL WASHERIES BASED ON MIDDLINGS.	5	500	2,500	6,500	6,000	4,830	42,300	460	33·4	60·8	94·20	2·23							
				6,500	6,000		42,300						14,271·75	10,960	7,130	62,500	1,027·88	129·70	2·07

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TABLE

POWER

PHASE	NAME OF STATION	HYDRO									
		INSTALLED CAPACITY				Available peaking capacity (MW).	Firm power at 100 % L. F. (MW).	Units generated 10^6 KWH	Capital cost power portion (Rs. Crores).	Annual charges (Rs. Crores) (a).	Cost per unit generated (nP.)
		No.	Size (MW)	Total new installation (MW).	Total installed at station (MW).						
	GROUP A										
	HIRAKUD SYSTEM ..				427·5	427·5	128	1,120	64·68	4·2	3·78
	MACHKUND ..				114·75	42·2	35·3	310	6·0	0 39	1 26
	BALIMELA ..				480	480	138	1,210	32·92	2·14	1 78
	GROUP B										
	TIKERPARA ..	22	125		2,750	2,750	825	7,230	155·0	9·92	1·38
	TULSIPUR ..	3	93		279	279	83·6	733	18·31	1·2	1·63
	TANGI ..	10	125		1,250	1,250	346	3,025	94·84	6·16	2·04
	TIKRA ..	1	6		6	6	5·25	46	1·51	0·098	2·14
	GROUP C										
	INDRAVATI ..	10	78		780	780	234	2,050	43·5	2·83	1 38
V	UPPER KOLAB ..	4	66		264	264	79	693	16·0	1·045	1·5
	DEOGAON ..	4	30		120	120	36	311	18	1·04	3 34
	GROUP D										
	BARKOTE ..				1,053	1,053	315	2,760	91·01	5·92	2·14
	LOWER KOLAB ..				367·5	367·5	110 35	965	26·11	1·695	1 76
	GROUP E										
	BHIMKUND										
	DAM POWER-HOUSE	2	42	84							
	POWER-HOUSE II ..	4	75	300							
	POWER-HOUSE III ..	4	60	240							
	TOTAL—BHIMKUND				624	624	182·6	1,600	62·26		2·53
					8,513·75	8,443					

(a) DETAILS OF ANNUAL CHARGES—

		HYDRO	THERMAL
INTEREST%	..	4·5	4·5
DEPRECIATION%	..	1·0	2·3
OPERATION AND MAINTENANCE	..	1·0	0·5
TOTAL%	..	6·5	7·3

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DEVELOPMENT—*concld.*

NAME OF STATION	THERMAL: INSTALLED CAPACITY (1,000 K. W.): No.	Size (MW)	Total new installation (MW.)	Total installation (MW.)	Total less 8% for Auxiliaries	Firm power (MW.) (c)	Units generated 10^6 KWH.	Capital cost (Rs. Crores)	ANNUAL CHARGES (Rs. Crores): Fixed charges (a)	Coal (b)	Total	Cost per unit generated	INTEGRATED SYSTEM HYDRO AND THERMAL: CAPACITY (1,000 KW,): Total installed capacity	Peaking exclusive of 20 reserve—	Firm Power (c)	Units generated 10^8 KWH.	Capital cost (Rs. Crores) (d)	Annual charges (Rs. Crores) (a).	Generated cost per Unit nP.
	4	62·5																	
	2	125																	
	4	250																	
	5	500																	
TALCHER OR THERMAL STATION IN BIHAR-BENGAL WASHERIES BASED ON MIDDLINGS.	5	500	2,500	9,000	8,280	6,120	53,600	635	46·5	67·6	114·1	2·13							
				9,000	8,280		53,600						17,515·75	13,276	8,630	75,600	1,268·14	153·903	2·02

(*b*) COAL COST: Rs. 20 PER TONNE

(*c*) FIRM POWER UTILIZED IN INTEGRATED OPERATION

(*d*) INCLUDING INTERCONNECTING TRANSMISSION LINES

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PART II—THERMAL POWER PROJECTS

The justification for thermal power generation on a large scale arises:

firstly, because Talcher Coalfields are said to have a reserve of some 40,000 million tons of non-coking coals, the poorer qualities of which can be used for power generation to any extent, and also because it is stated that large quantities of middlings will be thrown up by the washeries in the Bihar-Bengal Coalfields, which will become available for the picking, for generation of relatively cheap thermal power and which, if not used for that purpose, will occupy space for disposal and cost money later to remove; and

secondly, because hydropower stations unless backed by thermal support in grid and thermal power stations unless, similarly backed by hydro support, will not be able to ensure maximum utilisation of installed capacity of either system, and will, therefore, not achieve maximum economy in generating costs.

As will be seen from the last columns of Tables 3 and 4 the unit cost of generation of hydro power is much less than that of thermal power. It is particularly so in case of the Tikerpara Project. For instance, unit costs of hydro generation at Tikerpara and thermal generation at Talcher (which will also be the cost of generation based on middlings at washeries for equal price of coal), as given in Table 4, compare as follows:—

TABLE 5

Phase	Hydro at Tikerpara			Thermal at Talcher or Washeries	
	Installed capacity (M. W.)	Cost of generation per Kwh. (nP.) (a)	(b)	Installed capacity (M. W.)	Cost of generation per Kwh. (nP.) (c)
II	1000	0·945	1·24	1500	2·32
III	2000	1·15	1·44	4000	2·18
IV	2750	1·38	1·66	6500	2·23
V	2750	1·38	1·66	9000	2·13

(*a*) Based on cost allocation to power (inset-bottom Table 3)

(*b*) If entire cost of dam charged to power and nothing to flood control or irrigation

(*c*) Based on cost of coal or middlings at Rs. 20 per ton, inclusive of transport costs, cesses and taxes, and 1·435 lbs. of coal required to generate one Kwh. The cost of 1·435 lbs. of coal $= \frac{1{\cdot}435 \times 20 \times 100}{2{,}240} = 1{\cdot}28$ nP.

Fuel cost, per unit, therefore, equals 1·280 nP. per Kwh.

(If cost of coal or middlings is reduced to Rs. 12 per ton, the fuel cost per unit will be $\frac{1{\cdot}280 \times 12}{20} = 0{\cdot}768$ nP.)

From the above it is obvious that the generation of hydro power which is much cheaper than thermal power and has the further advantage that the works constructed for this purpose will also serve the other vital purposes of flood control, irrigation, navigation, fish culture, tourism, etc., must receive first priority, particularly, if funds are limited.

Even where funds are avaliable and stream-flows still exist for generation of hydro power, thermal power will be justified only to the extent that it firms up hydro generation and permits maximum use of installed capacity. In cases where stream-flows

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are no more available for generation of hydro power, thermal generation is the only alternative for augmenting power supply to meet rising demand.

Where thermal electric power has to be generated in bulk for other reasons, such as the necessity to use up middlings thrownup by the washeries in the Bihar-Bengal coal-fields which will otherwise use space and cost money to remove, the important fact should be recognised that unless hydro power is available in grid to take the peak loads and otherwise cater to the wide fluctuations in load, the cost of thermal generation will rise unduly high.

Effort has been made towards striking a rational system balance between hydro and thermal generation (Tables 4 and 6). A system load factor of 65 per cent will obtain in phase IV and after, and of 70 per cent during phases I, II, and III. This may be summarised as follows:—

TABLE 6

INSTALLED CAPACITY M.W.

			Hydro*	Thermal	Total
Phase	I	..	902	500	1.402
Phase	II	..	3,557	1,500	5,057
Phase	III	..	5,721	4,000	9,721
Phase	IV	..	7,892	6,500	14,392
Phase	V	..	8,443	9,000	17,443

Table 6 will be valid on the presumption that funds are available for thermal generation in addition to hydro generation and irrigation in accordance with the above proposed phasing. The pattern of actual thermal development, in addition to 500 M.W. at Talcher which will be installed in any case, will of necessity have to follow the pattern of financial allocations in this respect. Tables 7 and 8 explain.

COST AND BENEFITS OF THE MAY 1963—MASTER PLAN

For purpose of assessment of the economic justification of various components of the Master Plan in relation to availability of resources, the Plan may be divided into the following five component combinations:—

C. C. 1 Projects completed or under construction as given in Group A of Table 3 plus 250 M. W. thermal generation at Talcher of Table 4.

C. C. 2 New River Valley Projects, which constitute the Core of the Master Plan and, therefore, must have the highest priority, given in Group B of Table 3 plus another 250 M.W. thermal generation at Talcher bringing the total thermal to 500 M.W.

C. C. 3 All new River Valley Projects included under Groups B, C, D and E.

C. C. 4 All new River Valley Projects included under Groups B, C, D and E, including the 250 M.W. thermal plant under C. C. 2 above plus thermal generation of additional 8,500 M.W.

C. C. 5 The Total Plan.

* Installation at 30 per cent load factor.

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The cost and benefit figures of the various components and component obtained from Tables 3 and 4 :—

TABLE

Serial No.	Group	River Valley Project Hydro Power and Irrigation					
		Benefits			Cost Rs. crores		
		Flood Control	Irrigation (a) 000 acres	Power M. W. at 30 per cent L. F. installed	Irrigation	Power	Total
1	2	3	4	5	6	7	8
1	A	Only Partial Mahanadi.	2,526	947·7	77·26	103·60	180·86
2	B	Complete Mahanandi.	5,274 (c) (6,500,	4,285·0	144·65	304·66	449·31
3	C	Nil ..	880	1,164·0	26·77	77·50	104·27
4	D	Complete Brahmani.	1,053	1,420·5	70·60	117·12	187·72
5	E	Complete Baitarani.	61	624·0	1·90	62·26	64·16
6	Total—B+C+D+E.	Complete Mahanadi, Brahmani, Baitarani.	7,268 (c) (8,500)	7,493·5	243·92	561·54	805·46
7	Thermal ..						
8	Total—B+C+D+E+Thermal.	As in (6) ..	7,268 (c) (8,500)	7,493·5	243·92	561·54	805·46
9	Grand Total—A+B+C+D+Thermal.	As in (6) ..	9,794 (c) (11,000)	8,443·2	321·18	665·14	986·32

NOTE—(a) *Kharif* plus *Rabi*

(b) Includes 35·00 crores for flood control

(c) It will be possible to add another 1 to 1·2 million acres for Irrigation in West Bengal and Andhra Pradesh bringing.

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combinations mentioned above are given in the following table, the data having been

7

Thermal Projects		Total of Hydro and Thermal Projects					Component combination (C. C.)
Cost Rs. crores	Power M. W. installed	Benefits		Cost Rs. crores			
		Irrigation (*a*) 000 acres	Power M. W. installed	Irrigation	Power	Total	
9	10	11	12	13	14	15	16
25·00	250·0	2,526	1,199·7	77·26	128·60	205 86	C. C. 1
20·00	250·0	5,274 (*c*) (6,500)	4,535·0	144·65	324·66	469·31	C. C. 2
		880	1,164·0	26·77	77·50	104·27	
		1,053	1,420·5	70·60	117·12	187·72	
		61	624·0	1·90	62·26	64·16	
20·00	250·0	7,268 (*c*) (8,500)	7,743·5	243·92	581·54	825·46	C. C. 3
590	8,500·0	..	8,500·0		590·00	590·00	
610	8,750·0	7,268 (*c*) (8,500)	16,243·5	243·92	1,171·54	1,415·46	C. C. 4
635	9,000·0	9,794 (*c*) (11,000)	17,443·2	321·18	1,300·14	1,621·32	C. C. 5

the total to 6·5 million acres (line 2), 8·5 million acres (line 6—8) and 11 million acres (line 9) respectively.

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The total cost of the Master Plan (exclusive of the cost of the industrial complex that will be established as a result of the development of power, irrigation and navigation under the Plan) has been estimated at Rs. 1,621·32 crores.

Of this, Rs. 205·86 crores is accounted for by projects already constructed or under construction, leaving Rs. 1,415·46 crores as the cost of new projects.

Thermal generation at Talcher will not be necessary beyond the 250 M.W. under installation (C.C.1) and the 250 M.W. included under C.C.2 (serial 2 Table 7) until the 7,743 M.W. of hydro power under C.C.3 (serial 6 of Table 7) which are the cheapest to generate, have been used up.

The total cost of projects under C.C.3 (serial 6—all new hydro projects plus 250 M.W. of additional thermal power) is estimated at Rs. 825·46 crores. This component-combination of the Master Plan estimated to cost Rs. 825·46 crores is, therefore, the one which needs consideration at this stage. The balance of Rs. 590 crores for thermal generation may be left for consideration at a later date.

For implementation, however, Orissa must proceed forthwith with the core projects of the **Plan** (C.C. 2,) namely, Group A plus the additional 250 M.W. of thermal power (serial 2 Table 7) estimated to cost Rs. 469·31 crores.

THE T. V. A. OF U. S. A.

It was in 1933 that the U. S. Congress set the Tennessee Valley Authority to the task of developing the resources of the Tennessee Valley. The T. V. A. has cost 1·757 billion dollars to the end of 1962, the equivalent of Rs. 842 crores (at Rs. 4·79 to a dollar). It will be 30 years old this year.

The T. V. A., has tamed the once treacherous Tennessee river whose floods used to carry away top soil, houses and barns.

The waters of these rivers now provide one of the world's finest inland recreation areas and yield some 10 million pounds of fish per year.

The main stem dams have navigation locks permitting the passage of vessels with 9 feet drafts. Over 13 million tons of traffic moved on this waterway in 1962.

T. V. A. today has 31 major dams and hydro-electric plants and ten steam plants with installed capacity of 12 million K.W., of which 4 million K.W. is hydro and 8 million K.W. is steam, producing 60 billion Kwh. of power. The generating capacity of T. V. A amounts to 8 per cent of the total U. S. Capacity. The generation cost of its power is 2·1 mills (1·01 nP.) per Kwh. against 4·20 mills (2·02 nP.) of private utilities in U. S. A.

Hydro and Thermal Power

In 1951 eighteen years after start of construction work, about 85 per cent of the power produced by T. V. A. came from hydro-electric plants and the balance 15 per cent from

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steam electric plants, that is, 2·872 million K.W. hydro and 0·638 million K.W. thermal or a total of 3·51 million K.W. By the end of 1955, the T. V. A. system was supposed to reach 9·4 million K.W. of which slightly over 60 per cent would be steam electric.

The great expansion of thermal generation began when most of the hydro-potential had been developed and the growth in the electricity needs of the people went beyond the river's ability to produce hydro-power.

Achievement

The T. V. A. transformed the entire economy and life of the people living in the Tennessee Valley, covering 80,000 square miles in seven States. One of the most poverty-stricken and backward areas in U. S. A. in the thirties of this century (as Orissa is today) is now throbbing with life and is among the most prosperous regions in U. S. A.—progressive in agriculture, power, industry, navigation, fisheries, inland lakes and recreation centres and in living standards.

THE MASTER PLAN OF ORISSA

The 1963 Master Plan of Orissa will do all that and more. Estimated to cost 1,621 crores, it will provide complete control of floods of the Mahanadi, Brahmani and Baitarani rivers ; 1·25 million acres of reservoir area for recreation, tourism and fish culture; 1,230 miles of navigable inland waterways of say 9 feet draft running through the whole length and breadth of Orissa and terminating at Haldia Port in West Bengal and Visakhapatnam in Andhra Pradesh with links to Paradeep Port and the proposed Santrapur Port in Chilika Lake; 17·44 million K.W. of installed power capacity (8·44 million K.W. hydro and 9·0 million K.W. thermal); and what is more, irrigation water to 11 million acres (9·8+1·2) of crops (*Kharif* and *Rabi*), of which 9 million acres will be in Orissa and about one million acres each in West Bengal and Andhra Pradesh—in other words, 44 per cent greater installed power capacity than the T. V. A. and 11 million acres of irrigation crops against none on the T. V. A.

The Rs. 825 crores Component—Combination of Master Plan (C.C.3)

A more realistic comparison will be with the component combination—C.C.3, comprising all new projects for the development of the water resources of Orissa for purposes of flood control, irrigation, power, navigation, fish culture, tourism, etc., with 250 M.W. of additional thermal power generation at Talcher.

This component combination is estimated to cost Rs. 825·46 crores (total cost of T. V. A. 842 crores) and will provide :

complete flood control of the Mahanadi , Brahmani and Baitarani rivers ;
1,250,000 acres of additional reservoir area for fish culture, recreational and tourism facilities;
1,230 miles of navigable inland waterways ;
a new port at Santrapur in Chilika Lake;
7·74 million K.W. of additional installed power, of which 0·25 million K.W. will be thermal at Talcher and the remaining hydro ;

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8·5 million acres of new irrigation (*Kharif* plus *Rabi*) of which 7·5 million acres will be in Orissa and about 1 million acres each in West Bengal and Andhra Pradesh:

the figures of power being over twice those on the T. V. A. in 1951 and somewhat less than those in 1955, the figures of irrigation being 8·5 million acres against none in T. V. A.

The Rs. 469 Crores Component of Master Plan (C.C. 2)

The most attractive component—C.C. 2, which should be considered and undertaken for implementation forthwith consists of projects under Group A (serial 2 Table 7), estimated to cost Rs. 469·31 crores and to provide benefits:

complete flood control of Mahanadi river;

654,000 acres of reservoir area for fish culture, recreation, tourism, etc.:

6·5 million acres of irrigation (*Kharif*+*Rabi*) of which 2 million acres will be in West Bengal and Andhra Pradesh;

4·54 million K.W. of installed power;

795 miles of navigable waterways and the new Santrapur Port all linked to Haldia, Visakhapatnam and Paradeep Ports.

The Rs. 175 Crores Sub-Component

Of the Rs. 469 crores component of the Master Plan the part of which must be taken up for construction immediately is the Tikerpara power Project, estimated to cost Rs. 175 crores. This component will provide:—

complete flood control of Mahanadi river;

654,000 acres of reservoir area for fish culture, recreation, tourism, etc., but no irrigation.

This sub-component is dealt with in greater detail in the pages that follow.

PRIORITIES AND PROGRAMME OF IMPLEMENTATION

The priorities in broad terms are indicated in Table 3 and consolidated in Table 7 The first priority goes to the Tikerpara-Gania Project and the Tikra Project under Group B. A further description of this group is given in subsequent pages.

The generation of thermal power beyond 500 M.W. at Talcher will come last in order of priorities, but if thermal power is to be generated based on middlings, this can be developed as required but will be outside the Orissa Plan.

Assuming that financial resources will be available, to the extent indicated in Table 8, the schematic programme of implementation may be somewhat as below—

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TABLE 8

PROGRAMME OF IMPLEMENTATION

Five-Year Plan	Period	Group (Tables 3 and 7)	Allocations Rs. in crores	Name of Project	Status of implementation
1	2	3	4	5	6
IIIrd	1963—66 (ORISSA'S DECADE OF DESTINY 1963—73)	B	15 (15)	Tikerpara Dam Gania Barrage Power Plant hydro.	Detailed investigations in progress. Project report submitted and authorised. Preliminary works for construction like roads, railways, workshops, power supply, housing, offices, etc., started and tenders for machinery and power plant issued.
IVth	1966—71	B	130 (145)	Gania Barrage canal system. Tikra Dam Talcher Thermal 250 M. W.	Tikerpara Dam Stage-I completed and Stage-I Power Units installed. Gania Barrage built to essential minimum level. Survey, investigation and designs of Gania Barrage canal system and ground layout completed, project submitted and authorised. Preliminaries or Tikra Dam Project started.
Vth	1971—73	B	75 (220)	..	Tikerpara Dam completed. More power units being installed. Gania Barrage, further work in progress. Work in canal system started.
	1973—76	C	115 (335)	Indravati	Gania Barrage completed and work on canals progressing; 2,000 M. W. power units installed at Tikerpara Dam. Tikra Dam completed. Indravati Project started.
VIth	1976—81	C B B D	285 (620)	Upper Kolab Deogaon-Rampur Tulsipur and Tangi hydro power stations. Barkot	Indravati Project completed. Gania Barrage canal system completed. Upper Kolab completed. Deogaon Barrage, Deogaon-Rampur canals and power station completed. Tulsipur and Tangi Power Houses completed. Barkot Dam started.
VIIth	1981—86	D E	205 (825)	Lower Kolab Bhimkund	Barkot Dam Power Stations and canal system completed. Lower Kolab completed. Bhimkund completed with power units.
		Thermal	245 (1070)	Thermal Units 8,500 M. W.	Thermal units being progressively installed
VIIIth	1986—91	Thermal	345 (1415)	Thermal Units continued.	Thermal units completed. Master Plan completed.

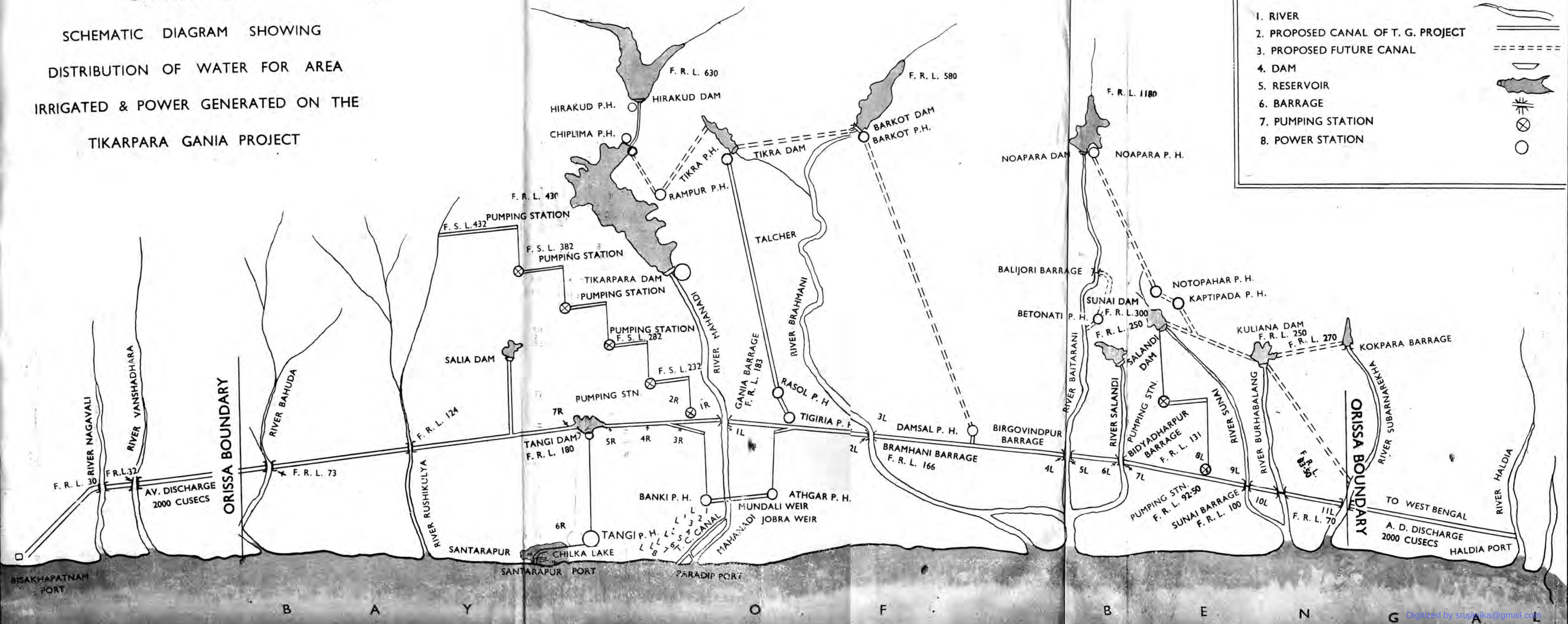
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DETAILS FOR PLATE IV

Name of Project		Location between	Annual Irrigation in 1,000 acres	Irrigation during: Kharif in 1,000 acres	Irrigation during: Rabi in 1,000 acres	Average discharge During: Kharif in cusecs	Average discharge During: Rabi in cusecs	Average supplementation during: Kharif in Cusecs	Average supplementation during: Rabi in Cusecs
Tikarpara-Gania	Left	MAHANADI, BRAHMANI .	316·8	198·0	118·8	1,980	700		
		BRAHMANI, BAITARANI	275·2	172·0	103·2	1,720	610	From Brahmani 4,000.	
		BAITARANI, SALANDI	195·2	122·0	73·2	1.220	430	From Baitarani 2,000.	
		SALANDI, SUNAI	529·6	331·0	198·6	3,310	1,170	From Salandi 600.	From Salandi 600.
		LIFT AREA IN BURAH-BALANGA BASIN.	627·2	392·0	239·2	3,920	1,380	Subarnarekha 2,500.	
		SUNAI, SUBARNAREKHA	401·6	251·0	150·6	2,510	13,890	From Sunai 400.	From Sunai 400.
		BEYOND. SUBARNAREKHA	80·0	50·0	30·0	500	180		
	Right	LIFT AREA	310·4	194·0	116·4	1,940	680		
		MAHANADI. TANGI . . .	384·0	240·0	144·0	2,400	850		
		TANGI, BAHUDA	620·8	388·0	332·8	3.880	1,370	From Salia 140.	From Salia 1,400.
		DELTA	2,134·4	1,334·0	800·4	16,500	7,900		
		TOTAL	5,875·2	3,672·0	2,203·2	39,880	16,160		
Barkot	Left	BRAHMANI, BAITARANI . .	480·0	300·0	180·0	3,000	1,060		
	Right	BRAHMANI, MAHANADI . .	412·8	258·0	154·8	2,580	910		
Tikra		TIKRA, ANGUL . .	141·0	88·0	53·0	880	320		
		TOTAL . .	1,033·8	646·0	387·8	6,460	2,290		

Name of power-house	Discharge in cusecs	Head in Feet	Power Q×H—100% / 14 (M. W.)	Installed Capacity @30% L.F. (M. W.)	Name of power-house	Discharge in cusecs	Head in feet	Power Q×H—100% / 14 (M. W.)	Installed Capacity @30% L. F. (M. W.)
TIKARPARA . .	55,000	210	825	2,750	ATHGARH . .	1,500	90	9·65	32
TULSIPUR	12,200	96	83·6	279	RAMPUR UPPER.	5,960	43	61·0	203
TANGI	29,160	166	345	1,250	TIKERPARA EXTRA.	5,660	210	85	250
BARKOT	2,700	170	21·2	71	TANGI EXTRA	5,370	166	63·6	250
					NOAPARA	3,200	110	25·1	84
DAMSAL	1,500	250	26·8	90	BETNATI . .	3,200	650	157·5	[illegible]
TIKRA	3,100	103	22·8	76·0	NOTOPAHAR	2,500	420	87	300
RASOL	1,500	157	16·8	56	KAPTIPADA . .	2,800	340	70·5	240
TIGRIA	1,500	76	8·15	28	RAMPUR LOWER.	10,000	50	36·0	120

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DETAILS FOR PLATE IV—*concld.*

Sl. No.	Reference	Designed discharge of canal in cusec	Average kharif discharge in cusec	Average rabi discharge in cusec	Annual average discharge in cusec	G. T. S. level
1	1 L	15,770	8,660	4,360	7,010	182·50
2	2 L	12,940	6,680	4,660	7,070	166·50
3	3 L	16,940	10,680	4,660	7,670	165·50
4	4 L	14,480	8,960	4,050	6,510	144·50
5	5 L	16,480	10,960	4,050	7,510	143·50
6	6 L	14,740	9,740	3,620	6,680	131·50
7	7 L	15,340	10,340	4,220	7,280	130·50
8	8 L	2,700	1,020	980	1,000	200·00
9	9 L	7,910	6,010	2,070	4,040	100·50
10	10 L	7,910	6,010	2,070	4,040	99·50
11	11 L	4,320	3,500	1,180	2,340	70·00
12	1 R	51,440	47,140	50,440	48,790	182·50
13	2 R	2,490	1,940	680	1,390	232·00
14	3 R	19,000	16,500	7,900	12,200	181·50
15	4 R	42,860	28,700	41,860	35,280	181·50
16	5 R	42,010	26,300	41,010	33,650	180·00
17	6 R	40,780	19,560	38,780	29,160	10·00
18	7 R	5,400	6,740	2,230	4,490	180·00

DETAILS OF LOCKS IN TALDANDA CANAL

Sl. No.	Notation	Name of Locks	Drop F. T.	Sl. No.	Notation	Name of Locks	Drop F. T.
1	L 1	HEAD LOCK AT JOBRA	1·05	5	L 5	TIRTOL LOCK	7·37
2	L 2	BIRIBATI LOCK	8·18	6	L 6	TALDANDA LOCK ..	3·72
3	L 3	SONEPUR LOCK	5·06	7	L 7	PARADIP EXTN. LOCK	6·00
4	L 4	TARAPUR LOCK	4·04	8	L 8	ATHARBANKI LOCK ..	About 6

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THE TIKERPARA-GANIA PROJECT

This Project will consist of—

- the Tikerpara Dam across the River Mahanadi 100 miles down stream of Hirakud:
- the Gania Barrage 22 miles downstream of the Tikerpara Dam:
- right bank irrigation-*cum*-navigation canal from the Gania Barrage passing through the Puri and Ganjam districts over barrages at the river crossings and terminating possibly at the Visakhapatnam Port:
- left bank irrigation-*cum*-navigation canal crossing the Brahmani, the Baitarani, the Subarnrekha and other minor rivers over barrage and terminating at the Haldia Port :
- power plants and locks at the various falls; and
- pumping stations for lift irrigation on both canals—in Mayurbhanj district on left bank canal and in Puri and Ganjam districts on right bank canal.

The Tikarapara Dam will be in three parts; one a masonry dam across the main river channel 4,170 feet long at crest, the second a masonary or possibly rock-fill dam 70 feet high and 820 feet in length at crest, and the third a masonry or possibly a rock filled dam 120 feet high and 5,000 feet long at crest. The crest level of the dam will be at elevation 450 and reservoir level at elevation 430, the same as the tail-race water level of Chiplima Power Station. It will provide a gross storage of 47 million acre-feet and a alive storage of 38 million acre-feet with a waterspread of about 1,000 square miles.

The capacity of each length of canal, the full supply levels, falls, power installed, pumping lifts, and details of irrigation are given in Plate IV and accompanying tables.

There are some noteworthy features of the Right Bank Canal. It will feed two major power plants, one at Tulsipur (discharge 12,200 cusecs, head 96 feet and installed power capacity 279 M.W.) tailing into the Mahanadi river above Mundali weir, the second at Tangi (discharge 29,160 cusecs, head 166 feet and installed power capacity 1,250 M.W.) tailing into the Chilika lake through a 40—50 feet deep channel into the sea. At the mouth of this tail channel will be a deep sea port—the Santrapur Port. The Chilika lake will be divided by this channel and its bund on its south bank into two parts—one of fresh water in an area of about 80 square miles and the balance of brackish water. The lake will be developed for fresh water and brackish water fishes and for industrial establishments on its periphery.

The actual distribution of water-supplies between the Tulsipur and Tangi canals and power houses will be adjusted to suit the needs of irrigation and the maintenance of proper regime of the Mahanadi river below Mundali weir.

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THE TIKERPARA POWER PROJECT

In view of the limitation of funds, as also of the urgency of making a start with the construction of parts of the Tikerpara-Gania Project, it is proposed to take up this very large project as two separate projects, namely:—

The Tikerpara Dam Project purely as a power project,

The Gania Barrage Project as an Irrigation-*cum*-Power Project ;

and also to implement each project in stages, such that each stage on completion starts bringing substantial benefits and financial returns and enables implementation of the subsequent stage or stages later without involving technical and constructional difficulties or undue additional expenditure. Also, the aim is to utilise the return from an earlier stage of the project for financing a good part of the expenditure for the next stage.

The Tikerpara-Gania Project has accordingly been studied as two separate projects. Also each of the two projects has been studied for construction in stages in line with the requirement set forth above. This study has confirmed that stage development is economical and technically feasible in respect of both projects.

In respect of the Tikerpara Power Project, the returns from the first stage will provide some resources for the implementation of its second stage and, from the second stage, ample resources for the implementation of the other component units of the Master Plan.

There will be a net return of—

Rs. 3·95 crores per year on completion of Stage-I, estimated to cost Rs. 108·15 crores, and

Rs. 39·45 crores per year on completion of Stage-II (final stage), estimated to cost Rs. 174·97 crores (*see* Table 10).

This study has also revealed that the construction of the Tikerpara Dam must be the very first work to be taken up, whether it be the project for generation of power at Tikerpara or the project for the extending of irrigation from the Gania Barrage canal system and the develpoment of power on that system.

The Tikerpara Power Project will, as indicated above, be completed in two stages—

the first stage to comprise construction of the dam to optimum minimum height, which will enable maximum generation of power with minimum submergence of land, thus keeping the capital investment to the barest minimum and at the same time bringing substantial financial returns;

the second stage to comprise construction of the dam to the full height and the installation of power units to full design capacity, in other words, the completion of the project in every respect. At this stage, the entire area under the reservoir at full design level will have to be submerged and full expenditure incurred on compensation and rehabilitation.

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STAGE-I

The optimum minimum level of storage in the first stage works out to elevation 355. With a spillway crest at elevation 340, the maximum flood of 2·7 million cusecs, which is supposed to occur once in 1,000 years, will rise to maximum El. 373 and will stand at that level for a couple of hours. The Sonepur town which is at El. 370 and above will, therefore, remain above the maximum flood rise. Its lower lands, may, however, have to be protected by an embankment of no more than 5 feet high.

Land in the first stage may be acquired to RL. 355, to which level the reservoir can be filled when the floods have passed. It may be noted that the flood discharge considered above is of the magnitude of 2·7 million cusecs, as against the maximum observed flood discharge of 1·36 million cusecs. This latter flood will not rise appreciably above elevation 355.

The Dam will be constructed to full section from foundations up to spillway crest level El. 340 in the spillway portion and up to safe level El. 380 or 40 feet above crest level for the rest of the Dam to prevent over-topping during maximum floods.

For obtaining a reservoir level of 355, shutters 15 feet high will be installed as a temporary measure over the spillway crest in the river bed and the spillway at Saddle-I.

All penstocks will be installed in the entire power dam including portions where generating units are to be installed after Stage-I.

All work in connection with the Power House up to about El. 190·0 will be completed, including the tail race channel. This latter becomes necessary to permit the construction of the Gania Barrage, with its designed pond level at 183·0, being undertaken at any stage. Once the barrage is constructed, the pond level cannot be lowered below 183, otherwise both irrigation and power generation from the canal system will either stop entirely or be seriously affected.

Also, the Gania Barrage must be completed as far as possible before the first stage of the Dam becomes operative. If the barrage were to be constructed ahead of filling up the reservoir for the Stage-I of the dam, its closing phase of construction will have to deal with a manageable river discharge of about 9,830 cusecs as released from the Hirakud Dam. If the barrage is constructed after completion of Stage-I of the Dam, its closing phase of construction will have to deal with about 23,820 cusecs discharge. This will be quite a big discharge and difficult to handle. But when the Dam is completed and the final stage becomes operative, the final closure will have to deal with a discharge of 55,000 cusecs, a most difficult and expensive undertaking. It will, therefore, be necessary to complete the river part of the barrage, simultaneously with the filling of the reservoir for Stage -I. A provision of Rs. 8 crores has been made for this.

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STAGE-II

The works left over after the completion of Stage-I will be the completion of the dam in the river section to full height; the construction of masonry or rockfill dams over saddles 2 and 1 and the installation of the remaining power units. The additional cost involved in this will be : (*See* Table 10).

Civil works	6·30	Crores
Land	30·00	,,
Power generation	24·38	,,
Overhead charges	6·14	,,
Total	66·82	,,

The cost of completing the entire dam and ancillary works after completing Stage-I will thus be only 6·30 crores, which can well be finished in a year. After the reservoir is raised gradually, the installation of power units can continue to suit load demands and the reservoir level proposed for the year, and thereby the investment on power and expenditure on land acquisition and rehabilitation can be spread over a longer period.

The cost and benefits of Stage-I and Stage-II are given below:—

TABLE 10

	Stage-I	Stage-II
Reservoir levels	355	430
Capital Cost		
Civil Works (Rs. crores).	43·96	50·26
Land ,,	25·00	55·00
Electrical Works ,,	30·45	54·83
Overhead charges ,,	8·74	14·88
Total	108·15(*a*)	174·97(*b*)

NOTE—(*a*) Foreign exchange component .. Rs. 15·0 crores.
(*b*) Foreign exchange component .. Rs. 20·5 crores.

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TABLE 10—*contd.*

Power		Stage-I	Stage-II
Firm power at 100 L.F. (M.W.)	..	286	825
Installed capacity (M.W.)	..	750	2,000
Peak availability (M.W.)	..	558	2,000
Maximum demand at 70 per cent L.F. (M.W.)	..	409	2,000
Cost of generation per K.W.H. (nP.)	..	2·53	1·46
Financial Returns			
Receipts @ Rs. 250 per K.W. year of maximum demand (Rs. crores)	..	10·2	50·00
Interest, maintenance, depreciation, etc., per year (Rs. crores)	..	6·25	10·44
Net return per year (Rs. crores)		3·95	39·56

In view of the present acute power shortage and the mounting demand of anticipated loads of industrial and other undertakings already approved or likely to be approved, there is every likelihood that the 409 M.W. of available power (70 per cent load factor) in Stage-I will be committed even before it becomes actually available, and that there will be a pressing need for the installation of additional units. Since the dam can be completed in a year or so after completion of Stage-I, the work of sub-structure of power house, including penstocks, and embedded parts having been already completed under Stage-I, the installation of additional units to the full capacity of 2,000 M.W. will be a relatively simple matter, the total additional cost involved in electrical installations being Rs. 24·38 crores.

As will be seen from Table 10, the gross return on completion of Stage-II will be Rs. 50 crores a year. After deducting Rs. 10·44 crores for interest, maintenance and depreciation costs per year, the net return will be Rs. 39·56 crores a year.

THIS NET RETURN OF NEARLY 40 CRORES A YEAR WILL TRANSFORM THE ECONOMY OF ORISSA INTO A SELF GENERATING ONE, ENABLING THE BALANCE OF THE MASTER PLAN TO BE LARGELY EXECUTED WITH THE RESOURCES GENERATED FROM THE TIKERPARA POWER PROJECT.

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TABLE 11

SALIENT FEATURES OF TIKARPARA POWER PROJECT

	Stage-I	Stage-II
I. General—		
Maximum estimated flood		2·70 million cusecs
Maximum observed flood		1·36 million cusecs
Maximum observed flood level		R. L. 230·00
Minimum water level		R. L. 173·00
Lowest bed level		R. L. 145·00
Rock bed level (average)		R. L. 140·00
Width of river at R. L. 176		1,460 ft.
Width of river at R. L. 450		4,170 ft.
II. Reservoir—	Stage-I	Stage-II
Top of dam	R. L. 380·00	R. L. 450·00
Maximum water level	R. L. 373·00	R. L. 440·00
Full reservoir level	R. L. 355·00	R. L. 430·00
Spillway crest level	R. L. 340·00	R. L. 395·00
Dead storage level	R. L. 315·00	R. L. 330·00
Storage capacity at F. R. L.	14·00 Macft.	47·00 Macft.
Live storage	7·40 Macft.	38·00 Macft.
Regulated perennial flow	23,820 Cusecs	55,000 Cusecs
Average head for power	168 ft.	210 ft.
III. Main Dam—		
Total length at top of Dam ..	3,900 ft.	4,170 ft.
Non-overflow dam (including power Dam).	1,920 ft.	2,190 ft.
Spillway (Central)	1,980 ft.	1,980 ft.
Saddle Spillway	1,500 ft.	Nil
Saddle Dams		
I		5,000 ft.
II		820 ft.
IV. Power—		
Firm power at 100 per cent L. F.	286 M.W.	825 M.W.
Installed capacity	750 M.W.	2,000 M.W. (rising to 3,000M.W.)
Average tail water level—		
Post Gania Barrage ...	R. L. 185·00	R. L. 185·00
Pre-Gania Barrage ..	R. L. 175·00	R. L. 175·00
Estimated cost—Dam and Power Plant	108·15 Crores.	174·97 Crores.
Cost of generation/K. W. H. ..	2·53 nP.	1·46 nP.*
Maximum Demand at 70 per cent L. F.	409 M.W.	2,000 M.W.
Charge per KW., per year of maximum demand.	Rs. 250	Rs. 250

* This is with entire cost charged to power. If 40 crores charged to flood control and irrigation, the cost of generation per K.W.H. will be 1·17 nP.

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TABLE 11—*contd.*

(Rupees Crores)

V. Financial—	Stage-I	Stage-II
Capital Cost—Civil Works—		
A—Preliminary	0·32	0·32
C—Civil Works	33·10	39·40
K—Buildings	2·43	2·43
O—Miscellaneous	2·67	2·67
R—Communication ..	5·44	5·44
Total—Civil Works ..	43·96	50·26
Cost of land ..	25·00	55·00
Capital Cost—Electrical Works—		
1. Penstocks ..	3·83	3·83
2. Power House sub-structure including embeded parts of turbine	7·50	20·00 (items 2 and 3)
3. Civil Works for Power Plant	7·50	
4. Power Plant	9·00	24·00
5. Switch Gear ..	2·62	7·00
Total—Electrical Works ..	30·45	54·83
Overhead and Miscellaneous items—		
(*a*) Maintenance during construction ..	0·74	0·74
(*b*) Establishment T. & P. Audit and other unforeseen charges.	8·00	14·14
Total—Overhead and Miscellaneous	8·74	14·88
Total Cost—Dam and Power Plant	108·15	174·97*
Gross receipts per year ..	10·20	50·00
Fixed charges per year (for interest, maintenance, depreciation and interim replacement).	6·25	10·44
Net return per year	3·95	39·56

* Entire cost charged to power and none to flood control or irrigation

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RESETTLEMENT AND REHABILITATION

For the resettlement and rehabilitation of the oustees, it is proposed to reclaim Government lands, as far as possible close to the original habitations which will be submerged, and in all cases to provide such new areas with irrigation facilities, set up model villages or townships with appropriate industries and technical high schools, and to so arrange the programme of reclamation and rehabilitation that the oustees will have the option of moving into their new homes, farms and factories one or two years ahead of the date of actual submersion. This will ensure smooth and orderly movement of the people from the old to the new surroundings, which latter will be better and have better facilities for gainful employment.

The reclamation, building and industrial works will, as far as possible, be carried out by the prospective oustees, who will be encouraged to work in the reclamation of fields and building of homes which will ultimately be their's, and on building schools and factories in which they will get training and, finally, employment. This will give the oustees a feeling of participation and a sense of belonging and, at the same time, a definite fillip to rural industrialisation and rural uplift.

Rs. 25 crores have been provided for acquistion and rehabilitation for Stage-I and additional Rs. 30 crores for Stage-II of the Project, making a total of Rs. 55 crores.

Large areas of cultivable lands have been located in the forest areas of Dhenkanal, Sambalpur, Bolangir and Phulbani districts and plans for providing irrigation water to these from medium irrigation projects are under investigation and finalisation. These areas will be mostly on the fringes of the Tikerpara reservoir and therefore not far from the areas to be submerged. The search for similar other areas located somewhat further away, but with possibilities of being provided with irrigation water, is in progress.

DIVERSION OF WATER FOR IRRIGATION IN MADHYA PRADESH

26,880 square miles of the catchment area of the Mahanadi lies in Madhya Pradesh. Only a small quantity of water of that catchment has so far been tapped for purposes of irrigation in that State, although considerable areas in it may be in need of irrigation. Further diversions of the Mahanadi waters for irrigating these areas and for power generation in course of time are, therefore, inevitable.

Any storage for power in Madhya Pradesh will add to the flood control and power potential at Tikerpara and help save flood waters in wet and very wet years being wasted to the sea. But any diversions for irrigation, which involve consumptive use of waters will reduce the availability of water and, may, therefore, affect to some extent the power potential at Tikerpara. This may not happen until 15 to 25 years from now. The reduction in quantity of water-supply would be of no consequence so far as irrigation is concerned, as a good deal of water will in any case have to be escaped to the sea through the Mahanadi river or the Chilika lake. But the reduction in power potential as a result of reduced storage will need to be made up if the industrial and economic structure built on designed power availability has to be maintained at peak level. Fortunately, it will be possible to take care of this deficiency in full and more by the diversions of the Brahmani waters after the construction of the Barakot Dam (Group D), the work on which would, it is hoped, start soon after the completion of the Tikerpara Dam.

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TIKERPARA—A NATIONAL POWER PROJECT

The Tikerpara Project, with its potential for installation of nearly 3,000M.W. (at 30 per cent load factor) and later more when Indravati and Barakot dams and reservoirs with regulated discharges of 3,000 and 15,000 cusecs, respectively, are constructed and waters of these (about 18,000 cusecs) diverted into Tikerpara lake, is one which can serve not only Orissa, but all the neighbouring States, namely West Bengal, Bihar Madhya Pradesh, Andhra and possibly Uttar Pradesh and Maharashtra. In integration with the proposed thermal power generation based on Talcher coals and/or middlings from the Bihar-Bengal coal fields, the Tikerpara Power Station, which by itself will generate about the cheapest power, can enable maximum utilisation of the entire thermal capacity and its own, thereby making available in the aggregate much greater and cheaper usable power than would be the case, if the two sets of stations were to work in isolation.

Hydro-power, as stated earlier, is much cheaper to generate than thermal power and should have the highest priority.

It has been stated that by the end of the Fourth Plan, the availability of middlings from the washeries will rise to 20 million tons which will be enough to provide fuel for a 5 million K.W. thermal generating station. These middlings must necessarily be used to avoid national waste. But to back up this thermal generation, steps must simultaneously be taken to develop hydro-power, where it can be done in quantity and at cheap rates, to secure maximum utilisation of installed capacity, thermal as well as hydro and minimum cost of generation. As to what hydro-power has to be developed to provide the correct system balance between hydro and thermal for maximum utilisation will depend on the nature and location of loads.

The Tikerpara power project affords an ideal opportunity for developing such hydro-power to provide a rational system balance between hydro and thermal.

Therefore, apart from its own intrinsic justification in points of cost and returns, its immediate development becomes a necessity in the wider interests of the region and the country, in order that power becomes available as needed and at reasonable cost and there is no recurrence of the chronic power famine in the Eastern Region, which presently is standing in the way of industrial development.

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TABLE 12

(TIKERPARA RESERVOIR LEVELS, AREAS AND CAPACITIES)

Elevation	Area (Acres)	Capacity (m.a.f.)
310	119,000	6·00
315	*132,500*	*6·60*
320	145,000	7·40
325	158,000	8·20
330	171,500	9·00
335	185,000	9·85
340	*201,000*	*10·75*
345	217,000	11·65
350	237,000	12·75
355	*257,500*	*14·00*
360	278,000	15·75
365	302,500	17·50
430	*640,000*	*47·00*

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TABLE 13

TIKERPARA DAM

Cost of Works

Civil Works		Reservoir Levels 355	430
		Rs. in lakhs	
A—Preliminary investigation and exploratory and surveys		32·00	32·00
B—Land	..	25,00·00	55,00·00
C—Works—			
(*i*) Spillway Excavation—	..	1,21·68	1,21·68
Concrete and Masonry	..	13,50·89	14,36·79
Sluice gates	..	12·00	12·00
Piers and Bridges	..	..	12·60
Crest Gates	..	..	71·00
(*ii*) Power Dam—			
Excavation	..	26·82	26·82
Concrete and Masonry	..	4,06·24	4,52·24
(*iii*) Non Over flow Dam— Excavation	..	24·96	24·96
Concrete and Masonry	..	1,85·84	2,35·84
(*iv*) Training—			
Walls	..	40·00	40·00
(*v*) Tail Race	..	2,87·00	2,87·00
(*vi*) Drilling and grouting	..	1,00·00	1,00·00
(*vii*) Dewatering arrangements	..	75·00	75·00
(*viii*) Saddle Dam (rock fill)	..	..	3,52·00
(*ix*) Miscellaneous and unforeseen items	..	50·00	50·00
Total of Works	..	33,10·00	39,40·00
K—Buildings—Residential and Non-residential	..	2,43·00	2,43·00
O—Miscellaneous	..	2,67·00	2,67·00
R—Communications	..	5,44·00	5,44·00
Grand Total except 'B' Land	..	43,96·00	50,26·00

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TABLE 13—*contd.*

Hydro-Electrical Works

		(Rupees in lakhs)	
1. Penstocks	..	3,83·00	3,83·00
2. Power House Substructure to EL. 190·0, including embedded parts of turbine.		7,50·00	..
3. Civil Works for Power Plant	..	7,50·00	20,00·00
4. Power Plant	..	9,00·00	24,00·00
5. Switch Gear	..	2,62·00	7,00·00
Total—Electrical Works	..	30,45·00	54,83·00
Overheads and Miscellaneous items such as, maintenance during construction, establishment T & P, Audit and indirect charges, losses in stock, etc.		8,74·00	14,88·00
Grant Total—Dam and Power Plant	..	1,08,15·00	1,74,97·00

TABLE 14

TIKERPARA DAM

Abstract of Cost of Civil Plus Electrical Works

Reservoir Levels	..	355	430
Cost of Works		(Rupees in Crores)	
1. Civil Works (Table 2)	..	43·96	50·26
2. Cost of land (Table 2)	..	25·00	55·00
3. Hydro-Electric Installation	..	30·45	54·83
4. Overheads and Miscellaneous	..	8·74	14·88
Total—Cost of Dam and Power Plant	..	1,08·15	1,74·97

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TABLE 15

Fixed charges per year (on interest, maintenance and depreciation) based on U. S. Bureau of Reclamation Memorandum No. 1 :—
(Electrical Power Costs and Values)

Reservoir levels	..	355	430
		(Rupees in Crores)	
Capital Cost		108·15	174·97*
Annual Costs—			
1. Interest at 4·5 per cent	..	4·86	7·85
2. Depreciation (life of project 50 years amortisation) @ 0·50 per cent of investment.		0·61	0·98
3. Interim replacement @ 0·20 per cent of investment		0·22	0·35
4. Maintenance costs @ Rs. 7·62 per K.W. for 625 M.W. installed and @ Rs. 6·32 per K.W. for 2000 M.W. installed.		0·57	0·57
Total—Fixed charges	..	6·25	10·44
Units generated million K.W.H.	..	2,470	7,120
Cost per units generated (nP.)	..	2·53	1·46 *

Prevailing tariffs in Orissa for Power from Hirakud Grid

		Rs.	
Aluminium—First 25 M.W.	..	125	Per KW year of maximum demand
Second 23 M.W.	..	166	Ditto
Ferro-Manganese First 7·5 M.W.	..	210	Ditto
Balance	..	204	Ditto
Caustic Soda	..	350	Ditto
Low shaft furnace	..	360	Ditto
Cement factory, Railway, D. V. C. Bihar Stage } Average	..	550	Ditto

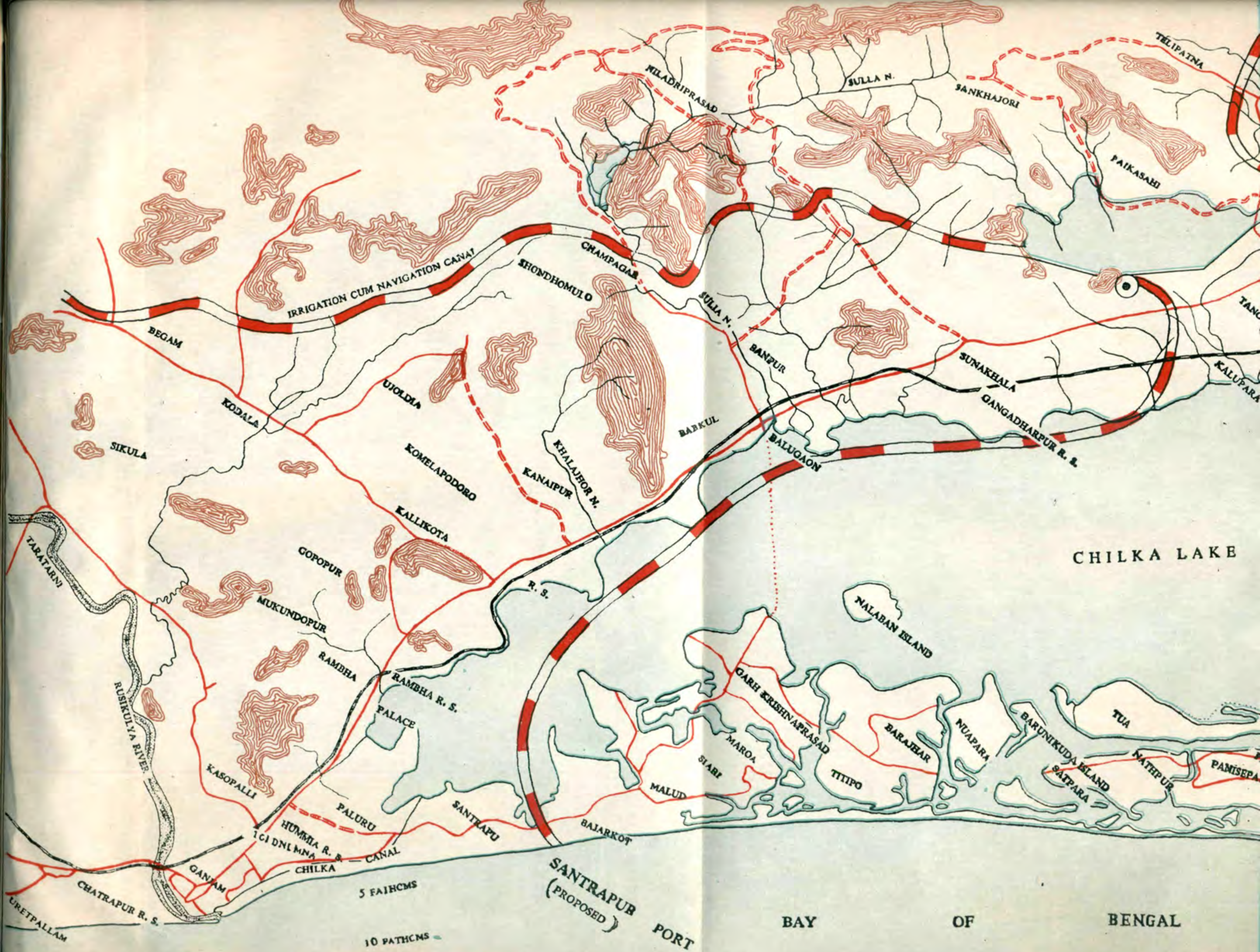
Electricity Board .. Made up of Rs. 5·50 per month plus energy charges @ 8 nP. per unit.

Steel Plant (Rourkela) .. Reservation charge Rs. 120 per K.W. year on peak demand, the energy being supplied on demand and returned to the same extent any time during the month so that there is no actual consumption of Hirakud energy by the Rourkela Steel Plant.

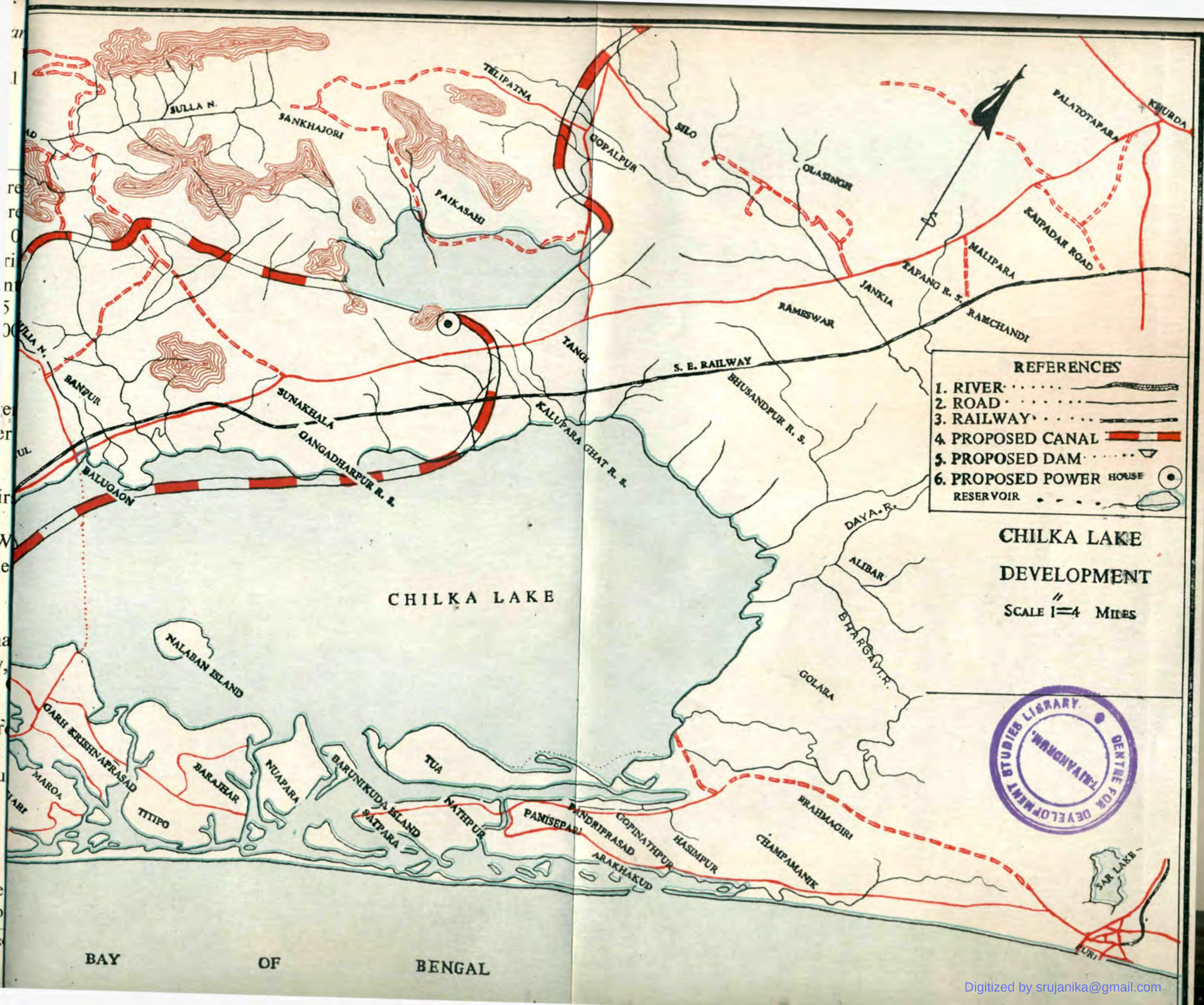
An average rate of Rs. 250 or even Rs. 275 per K.W. year of maximum demand would appear to be in order in the light of existing tariff given above.

* Total cost charged to power and none to flood control or irrigation.

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THE CHILIKA LAKE AND SANTRAPUR PORT

The Chilika Lake (Plate V) covers 450 to 500 square miles during the rains and about 350 square miles during the dry season. The water levels during these periods fluctuate between 3 and 6 feet.

The level difference between high tide and low tide is almost nil in the Northern Central and Southern sectors of the lake and ranges between 6 inches and 1·7 feet in the outer channels and 4 feet to 6 feet at the lake mouth.

The lake is connected to the sea at its north-east end, 2 miles north of Arkya-Kuda (14 miles from Puri) through an opening 300 feet wide and 6 to 30 feet deep. A new cut is being excavated to connect the Lake at its south-west end of the sea.

The Daya and Bhargavi rivers, two of the deltaic arms of the Mahanadi river, discharge their flood water into the Chilika Lake. With the construction of the Tikerpara Dam, the flooding will be stopped completely and only regulated supplies will be passed into the Lake, as required. Apart from these, there are only small nullahs discharging into the Lake during the rains.

As a result of the present fresh water flood discharges into the lake, the salinity in its various sectors varies. The maximum variation is in the northern (Kalupara Ghat) sector, which is affected by flood waters from Daya and Bhargavi, less in the central (Balugaon) sector and least in the southern (Rambha) sector. The outer channels near the sea have, of course, the highest salinity content.

The salinity content of sea water is 32 parts per thousand. The optimum salinity content for brackish water fish is said to be 15 parts per thousand and for fresh water fish less than 1 part per thousand. Fresh water fish generally breed in the north sector and brackish water fish in the rest of the lake, though, with changes in salinity, there is migration of either type into the other sector.

The sale prices of fishes are said to be generally as follows:—

Sea fish	..	Rs. 300 per ton
Brackish water fish	..	Rs. 1,000 per ton
Fresh water fish	..	Rs. 2,500 per ton

The lake yields about 3,500 tons of fish per year estimated to fetch about Rs. 60 lakhs. About 35,000 fishermen inhabiting 105 villages surround the lake.

The water depth in the lake ranges between 1·5 and 5 feet in the north sector, 5 to 7 feet in the central sector and 7 to 12 feet in the southern sector, the fringes in all cases being shallower. There appears to have been no appreciable change in the depths since 1860, except that some silting has taken place in the northern sector as a result of silt laden water brought by the Daya and Bhargavi floods.

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With the construction of the Gania irrigation-*cum*-power-*cum*-navigation canal there will be an average flow of about 29,000 (suitably adjusted to suit the regime requirements of the Mahandi river) cusecs of silt-free water passing through the Chilka Lake more or less throughout the year. It is proposed to carry this water through a dredged channel about 36 1/2 miles long, about 40 feet or more deep as need be, of which about 31 miles will be inside the lake and five miles outside it to the fall and power house near Tangi. The excavation from this channel will be deposited on its eastern side forming a continuous embankment 400 to 500 feet wide, which will divide the lake into two parts, the eastern part having brackish water and the western part, fresh water.

In the fresh water part, the level of water can be kept steady, if so desired, at or a couple of feet above high tide level by means of suitable navigation locks at the mouth of the channel. This fresh water part of the lake will be a potential port and protected harbour of about 80 square miles with about 32 miles of berthing space along the 40 to 50 feet deep dredged canal, a sizeable sheltered harbour near Rambha completely protected from cyclones, and a liberal additional harbour area for accommodating ships, submarines, dockyards, shipyards, etc. This fresh water harbour area will also be available for rearing fresh water fishes through properly planned fish farms. Deep sea fishing trawlers can find a safe haven in this part of the lake.

The wide embankment along the outfall channel will provide a road and/or rail link from the Calcutta-Madras main railway line at the northern end of the lake to its southern most end at its mouth into the sea. The area between the sea and the lake and the fringe areas on the land side of the lake will, with road, rail and water transport facilities provided, become available for setting up processing and heavy industries. Water for irrigation, domestic and industrial use can be supplied from the fresh water in the outfall channel.

The construction of the deep outfall channel has to be carried out in any case, as an integral part of the Tikerpara-Gania Project for purposes of irrigation and power. The other facilities such as berthing for ships, harbour facilities, dockyards and for ship building etc., are a by-product of this project and can be taken advântage of as and when the need for them arises.

It is felt that the mouth of the outfall channel will automatically remain clear almost to the excavated depth because of the perennial flow of about 29,000 cusecs of fresh and almost silt-free water. Should, however, it be decided to make use of the extensive harbour facilities already made available incidental to the irrigation and power project, and there be doubt about the width and depth of this mouth being maintained, the question of adding a breakwater or breakwaters can be considered at the appropriate time. The cost involved in this will be relatively small.

It may be noted that the five fathom contour of the sea is within about half a mile from the shore.

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